CONTRACT DOCUMENTS

FOR THE CONSTRUCTION OF

MAGNA WRF REUSE PROJECT

Volume 2 OF 4
Specifications

Magna Water District

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GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes general duty valves common to plumbing piping systems.

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections.

B. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. Ball Valves:
      a. Conbraco Industries, Inc.; Apollo Division.
      b. Milwaukee Valve Company, Inc.
      c. Hammond Valve.
      d. Kitz Corporation of America.
      e. Victaulic Company of America.
      f. NIBCO, Inc.
      g. Watts Industries, Inc.
   2. Plug Valves:

a. Grinnell Corp.
b. Hammond Valve.
c. Kitz Corporation of America.
d. Victaulic Company of America.

3. Globe Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Hammond Valve.
   c. Kitz Corporation of America.
   d. Milwaukee Valve Company, Inc.
   e. NIBCO Inc.
   f. Powell: Wm. Powell Company (The).
4. Butterfly Valves:
   a. Crane Company; Valves and Fitting Division.
   b. General Signal; DeZurik Unit.
   c. Grinnell Corp.
   d. Hammond Valve.
   e. Keystone Valve USA, Inc.
   f. Kitz Corporation of America.
   g. Line, Mark Controls Corporation.
   h. Milwaukee Valve Company, Inc.
   i. NIBCO Inc.
   j. ABZ Valves & Controls.
5. Swing Check Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Hammond Valve.
   c. Kitz Corporation of America.
   d. Milwaukee Valve Company, Inc.
   e. NIBCO, Inc.
   f. Powell: Wm. Powell Company (The).
   g. Victaulic Company of America.
   h. Watts Industries, Inc.
6. Silent Check Valves:
   a. Conbraco Industries, Inc.; Apollo Division.
   b. Hammond Valve.
   c. Keystone Valve USA, Inc.
   d. Metraflex Company.
   e. Milwaukee Valve Company, Inc.
   f. NIBCO Inc.
   g. Victaulic Company of America.
7. Lift Check Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Hammond Valve.
   c. Milwaukee Valve Company, Inc.
   d. NIBCO Inc.
   e. Powell: Wm. Powell Company (The).

2.2 BASIC, COMMON FEATURES

A. Design: Rising stem or rising outside screw and yoke stems, except as specified below.

1. Nonrising stem valves may be used only where headroom prevents full extension of rising stems.

B. Pressure and Temperature Ratings: As indicated in the "Application Schedule" of Part 3 of this Section and as required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Use specified operators and handwheels, except provide the following special operator features:
1. Handwheels: For valves other than quarter turn.
2. Lever Handles: For quarter-turn valves 6 inches and smaller, except for plug valves, which shall have square heads.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. Threads: ASME B1.20.1.

H. Flanges: ASME B16.1 for cast iron, ASME B16.5 for steel, and ASME B16.24 for bronze valves.

2.3 BALL VALVES

A. Ball Valves, 2 Inches and Smaller: MSS SP-110, Class 150, 600 psi CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, standard port for 1/2-inch valves and smaller and conventional port for 3/4-inch valves and larger; blowout proof; bronze or brass stem; Teflon seats and seals. Ball valves shall be full-port type for steam condensate applications as indicated.
1. Operator: Vinyl-covered steel lever handle.
2. Stem Extension: For valves installed in insulated piping.

B. End Connection: Threaded.

2.4 PLUG VALVES

A. Plug Valves: MSS SP-78, 175 psi CWP, ASTM A 126 cast-iron body and bonnet, cast-iron plug, Buna N, Viton, or Teflon packing, flanged or grooved end connections:
1. Operator: Square head with 1 wrench for every 10 valves.
2. Operator: Worm and gear with handwheel, sizes 6 inches and larger.
3. Operator: Worm and gear with chain wheel, sizes 6 inches and larger, 96 inches or higher above floor.

2.5 GLOBE VALVES

A. Globe Valves, 2 Inches and Smaller: MSS SP-80; Class 125, 200 psi CWP, or Class 150, 300 psi CWP; ASTM B 62 cast-bronze body and screwed bonnet, rubber, bronze, or Teflon disc,

silicon bronze-alloy stem, Teflon-impregnated packing with bronze nut, and with aluminum or malleable-iron handwheel.

B. End Connection: Threaded.

C. Globe Valves, 3 Inches and Larger: MSS SP-85, Class 125, 200 psi CWP, ASTM A 126 cast-iron body and bolted bonnet with bronze fittings, renewable bronze seat and disc, brass-alloy stem, outside screw and yoke, Teflon-impregnated packing with cast-iron follower, flanged end connections; and with cast-iron handwheel.

2.6 BUTTERFLY VALVES

A. Butterfly Valves: MSS SP-67, 200 psi CWP, 150 psi maximum pressure differential, ASTM A 126 cast-iron body and bonnet, extended neck, stainless-steel stem, EPDM sleeve and stem seals, wafer, lug, or grooved style:
   1. Disc Type: Nickel-plated ductile iron for HVAC and plumbing.
   2. Operator for Sizes 2 Inches to 6 Inches: Lever handle with latch lock.

B. Valves shall be capable of bubble-tight dead-end shut-off at full rated pressure without the need of a downstream blind flange.

2.7 CHECK VALVES

A. Swing Check Valves, 2 Inches and Smaller: MSS SP-80; Class 125, 200 psi CWP, or Class 150, 300 psi CWP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, rotating bronze disc with rubber seat or composition seat.

B. End Connection: Threaded.

C. Swing Check Valves, 2-1/2 Inches and Larger: MSS SP-71, Class 125, 200 psi CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc, flanged or grooved end connections.

D. Silent Check Valves: Class 125, 200 psi CWP, ASTM A 126 cast-iron body, bronze disc/plates, stainless steel pins and springs, Buna N seals, wafer or flanged style.

E. Lift Check Valves: Class 125, ASTM B 62 bronze body and cap (main components), horizontal or vertical pattern, lift-type, bronze disc or Buna N rubber disc with stainless-steel holder threaded or soldered end connections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION

A. Install valves as indicated, according to manufacturer's written instructions.

B. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above the center of the pipe.

E. Install valves in a position to allow full stem movement.

F. Installation of Check Valves: Install for proper direction of flow as follows:
1. Swing Check Valves: Horizontal position with hinge pin level.
2. Silent Check Valves: Horizontal or vertical position.
3. Lift Check Valve: With stem upright and plumb.

3.3 VALVE END SELECTION

A. Select valves with the following ends or types of pipe/tube connections:
1. Copper Tube Size, 2 Inches and Smaller: Threaded ends.
2. Steel Pipe Sizes, 2 Inches and Smaller: Threaded end.
3. Steel Pipe Sizes, 2-1/2 Inches and Larger: Flanged.

3.4 APPLICATION SCHEDULE

A. General Application: Use gate, ball, and butterfly valves for shutoff duty; globe, ball, and butterfly for throttling duty. Refer to piping system Specification Sections for specific valve applications and arrangements. Select trim to suit piping systems:

B. Domestic Water Systems: Use the following valve types.
1. Ball Valves: Class 150, 600 psi CWP, with stem extension.
2. Plug Valves: Neoprene-faced plug, Buna N packing.

3. Globe Valves: Class 125, bronze or cast-iron body to suit piping system, and bronze or Teflon disc.
4. Butterfly Valves: Nickel-plated ductile iron, aluminum bronze, or elastomer-coated ductile iron disc; EPDM or Buna N sleeve and stem seals.
5. Bronze Swing Check: Class 125, with rubber seat.
6. Check Valves: Class 125, swing or wafer type as indicated.

3.5 ADJUSTING

A. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

END OF SECTION

SECTION 22 11 16
DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes domestic water piping inside the building plumbing.

1.3 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Pipe and Fitting Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.3 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B 88, Types K and L, water tube, annealed temper.
   1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
   2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.
   3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
   4. Copper Press Seal-Fittings: Shall conform to the material requirements of ASME B16.22 copper and ASME B22.18 Bronze and the performance requirements of IAPMO PS117.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Elkhart Products Corporation.
         2) NIBCO, Inc.
         3) Tyco GRINNELL.
         4) Viega.
      b. Fittings for NPS 2 and Smaller: Wrought-copper or lead-free bronze fitting with EPDM sealing element in each end and un-pressed fitting leak identification feature.

B. Hard Copper Tube: ASTM B 88, Types L and M, water tube, drawn temper.
   1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought- copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
   2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping
   3. Copper Unions. MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
   4. Copper Press-Seal Fittings: Shall conform to the material requirements of ASME B16.18 bronze and ASME B16.22 copper, and the performance requirements of IAPMO PS117.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Elkhart Products Corporation.
         2) NIBCO, Inc.
         3) Tyco GRINNELL.
         4) Viega.
      b. Fittings for NPS 2 and Smaller: Wrought-copper or lead-free bronze fitting with EPDM sealing element in each end.

PART 3 - EXECUTION

3.1 PIPE AND FITTING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

B. Flanges may be used on aboveground piping, unless otherwise indicated.

C. Under Building slab, Domestic Water piping to 5feet outside of building, NPS 2 and smaller. Soft copper tube, Type K: copper pressure fittings; and brazed joints.

D. Aboveground Domestic Water Piping: Use the following piping materials:
   1. NPS 6 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
   2. NPS 1/2 to NPS 4: Hard copper tube, Type L; copper or lead-free bronze press-seal fittings.

3.2 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use bronze ball valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
   2. Throttling Duty: Use bronze ball or globe valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
   3. Drain Duty: Hose-end drain valves.
   4. Hot-Water-Piping, Balancing Duty: Calibrated balancing valves.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball valves for piping NPS 2 and smaller. Use butterfly valves for piping NPS 2-1/2 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
   1. Install hose-end drain valves at low points in water mains, risers, and branches.
   2. Install stop-and-waste drain valves where indicated.

D. Shutoff Duty: Use bronze press-seal ball valves for NPS 2 and smaller type L copper tube.

E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow.

3.3 PIPING INSTALLATION

A. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."

B. Install sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight.

C. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance.

D. Install water-pressure regulators downstream from shutoff valves.

E. Install domestic water piping level without pitch and plumb.

3.4 JOINT CONSTRUCTION

A. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

B. Press Seal Joints: Shall be installed using the most current edition of the manufacturer's installation guidelines. The factory trained representative shall periodically visit the jobsite, review the product installation and provide additional training if new manpower has been assigned to pressure-sealed-joint piping installation. Contractor shall remove and replace any improperly installed products.

3.5 HANGER AND SUPPORT INSTALLATION

A. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.

B. Install supports for vertical copper tubing every 10 feet.

C. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

D. Fire stopping shall be provided to both be compatible with the piping and meet the requirements of ASTM E 814 or ULC S115, "Fire Tests of Through-Penetration Firestops." Pipe insulations or fire resistive coating shall be removed where the pipe passes through a fire stop and, if required by the firestop manufacturer, for 3 inches beyond the firestop outside of the fire barrier.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve, and extend and connect to the following:
   1. Water Heaters: Cold-water supply and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   2. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code.
   3. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.7 FIELD QUALITY CONTROL

A. Inspect domestic water piping as follows:
   1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
      b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
   3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
   4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

B. Test domestic water piping as follows:
   1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
   6. Prepare reports for tests and required corrective action.

3.8 ADJUSTING

A. Perform the following adjustments before operation:
   1. Close drain valves, hydrants, and hose bibbs.
   2. Open shutoff valves to fully open position.
   3. Open throttling valves to proper setting.
   4. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
   5. Remove and clean strainer screens. Close drain valves and replace drain plugs.
   6. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
   7. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.9 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:
   1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:
         1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
         2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
      c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION

SECTION 22 11 19
DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following domestic water piping specialties:
   1. Backflow preventers.
   2. Water pressure reducing valves.
   3. Strainers.
   4. Drain valves.

1.3 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

C. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NSF Compliance:
   1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Ames Co.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Flomatic Corporation.
   e. Watts Industries, Inc.; Water Products Div.
   f. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1013. See Plumbing Fixture Schedule on Drawings.

2.2 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Cash Acme.
   b. Conbraco Industries, Inc.
   c. Honeywell Water Controls.
   d. Watts Industries, Inc.; Water Products Div.
   e. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig.
4. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.3 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Drain: Factory-installed, hose-end drain valve.

2.4 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves. See Plumbing Fixture Schedule on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Section 230500 “Common Work Results for Plumbing and HVAC” for piping joining material, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
   3. Do not install bypass piping around backflow preventers.

C. Install water control valves with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

D. Install water regulators with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

E. Install balancing valves in location s where they can easily by adjusted.

F. Install Y pattern strainers for water on supply side of each water pressure reducing valve.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:
   1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

END OF SECTION

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SECTION 22 13 16
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 80 pipe.

C. Adhesive Primer: ASTM F 656.
   1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Solvent Cement: ASTM D 2564.
   1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers"

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be

used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

K. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
   1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
   3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Plumbing Specialties:
   1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Comply with requirements for cleanouts specified in Division 22 Section "Sanitary Waste Piping Specialties."

N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

O. Install sleeves, sleeve seals and escutcheons for piping penetrations of walls, ceilings, and floors.

P. Install underground PVC piping according to ASTM D 2321.

3.2 JOINT CONSTRUCTION

A. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.3 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in OD's.
   2. In Drainage Piping: Unshielded or Shielded, nonpressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges or nipples.

3.4 HANGER AND SUPPORT INSTALLATION

A. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

D. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
2. NPS 3: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.

E. Install supports for vertical PVC piping every 48 inches.

F. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.6 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg . Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
   5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   6. Prepare reports for tests and required corrective action.

3.8 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

3.9 PIPING SCHEDULE

A. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:
   1. Hubless, cast-iron soil pipe and fittings heavy-duty hubless-piping couplings; and coupled joints.

B. Aboveground, vent piping NPS 4 and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.

C. Aboveground drain piping NPS 4 and smaller shall be any of the following:
   1. PVC pipe, PVC socket fittings, and solvent cemented joints.

D. Underground, soil, waste, and vent piping NPS 6 and smaller shall be any of the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI cast-iron hubless-piping couplings; and coupled joints.
   2. Solid wall PVC pipe: PVC socket fittings: and solvent cemented joints.

END OF SECTION 22 13 16

SECTION 22 13 19
SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following drainage piping specialties:
   1. Cleanouts.
   2. Floor drains, Floor sinks.
   3. Roof drains.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories.

B. Field quality-control test reports.

C. Operation and Maintenance Data: For drainage piping specialties to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary and storm piping specialty components.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Josam Company; Josam Div.
b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
c. Tyler Pipe; Wade Div.
d. Watts Drainage Products Inc.
e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. See Plumbing Fixture Schedule on drawings.
3. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Metal Floor Cleanouts:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Josam Company; Josam Div.
b. Oatey.
c. Sioux Chief Manufacturing Company, Inc.
d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
e. Tyler Pipe; Wade Div.
f. Watts Drainage Products Inc.
g. Zurn Plumbing Products Group; Specification Drainage Operation.
2. See Plumbing Fixture Schedule on drawings.

C. Cast-Iron Wall Cleanouts:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Josam Company; Josam Div.
b. MIFAB, Inc.
c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
d. Tyler Pipe; Wade Div.
e. Watts Drainage Products Inc.
f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M. Include wall access.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Josam Company; Josam Div.
      b. MIFAB, Inc.
      c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group; Specification Drainage Operation.
   2. Standard: ASME A112.6.3 and See Plumbing Fixture Schedule on drawings.

2.3 ROOF DRAINS

A. Metal Roof Drains:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Josam Company; Josam Div.
      b. MIFAB, Inc.
      c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group; Specification Drainage Operation.
   2. Standard: ASME A112.21.2M and See Plumbing Fixture Schedule on drawings.

2.4 MISCELLANEOUS DRAINAGE PIPING SPECIALTIES

A. Open Drains:
   1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
   2. Size: Same as connected waste piping.

B. Floor-Drain, Trap-Seal Primer Fittings:
   1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
   2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Air-Gap Fittings:
   1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
   2. Body: Bronze or cast iron.
   3. Inlet: Opening in top of body.
   4. Outlet: Larger than inlet.

5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Conductor Nozzles:
   1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
   2. Size: Same as connected conductor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Section 230500 "Common Work Results for HVAC" for piping joining materials, joint construction, and basic installation requirements.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
      a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
      b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
   3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
   4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

H. Install through-penetration firestop assemblies in plastic stacks at floor penetrations.

I. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
   1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Position roof drains for easy access and maintenance.

J. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
   1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
   2. Size: Same as floor drain inlet.

K. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

L. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

M. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Plumbing Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

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SECTION 22 14 13
STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following roof drainage piping inside the building for plumbing:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. LLDPE: Linear, low-density polyethylene plastic.

C. PE: Polyethylene plastic.

D. PVC: Polyvinyl chloride plastic.

E. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
   1. Storm Drainage Piping: 10 foot head of water.

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AB&I Foundry.
   2. Charlotte Pipe and Foundry Company.
   3. Tyler Pipe.

B. Above Grade Pipe and Fittings: All above grade Hubless Cast Iron Pipe and fittings shall conform to the requirements of CISPI Standard 301 and ASTM-888 and shall be marked with the Cast Iron Soil Pipe Institutes collective trademarks. All pipe & fittings shall be American made and tested, no imported pipe is acceptable.

C. Documentation: At the request of the engineer the manufacturer shall furnish the following information to confirm Compliance with CISPI 301:
   1. Radiation Screening records.
   2. Mechanical Testing records.
   3. Chemical Testing records.
   4. Dimensional Inspection reports.
   5. Certificate letter from manufacturer with legal name and address.

D. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
   1. Available Manufacturers:
      a. ANACO.
      b. Fernco, Inc.
      c. Ideal Div.; Stant Corp.
      d. Mission Rubber Co.
      e. Tyler Pipe; Soil Pipe Div.

E. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Available Manufacturers:
      a. ANACO.

2.3 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

2.4 SPECIAL PIPE FITTINGS

A. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
   1. Available Manufacturers:
      a. EBAA Iron Sales, Inc.
      b. Romac Industries, Inc.
      c. Star Pipe Products; Star Fittings Div.

B. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
   1. Available Manufacturers:
      a. SIGMA Corp.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground storm roof drainage piping NPS 2 to NPS 6 and smaller shall be any of the following:
   1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and coupled joints.
   2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

3.2 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Section 230500 "Common Work Results for Plumbing and HVAC."

B. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Plumbing Sections.

C. Install wall-penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.

D. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

E. Make changes in direction for storm piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of

standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

F. Lay buried building drain piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

G. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
   1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

H. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

I. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.3 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Section 230500 "Common Work Results for Plumbing and HVAC."

B. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

3.4 HANGER AND SUPPORT INSTALLATION

A. Pipe hangers and supports are specified in Section 230529 "Hangers and Supports for Plumbing Piping and HVAC Equipment." Install the following:
   1. Vertical Piping: MSS Type 8 or Type 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs: According to the following:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install supports according to Section 230529 "Hangers and Supports for Plumbing Piping and HVAC Equipment."

C. Support vertical piping and tubing at base and at each floor.

D. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

3.6 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   3. Test Procedure: Test storm drainage piping**,** except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10 foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   5. Prepare reports for tests and required corrective action.

3.7 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION

SECTION 22 34 00
FUEL-FIRED WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following fuel-fired water heaters:
   1. Commercial, storage, gas fired water heaters.
   2. Water heater accessories.

1.2 CONTRACTOR SUBMITTALS

A. In accordance with Section 01 33 20 – Contractor Submittals, provide product data for each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Operation and maintenance data and in accordance of 01 78 39 Product documents.

C. Warranty.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. Comply with NSF 61, "Drinking Water System Components – Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 COMMERCIAL, GAS WATER HEATERS

A. Commercial, High-Efficiency, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.
   1. Available Manufacturers:
      a. AERCO International.
      b. Bradford White Corporation.
      c. Lochinvar Corporation.
      d. Ruud Water Heater Div.; Rheem Manufacturing Company.
      e. Bock
      f. State Industries, Inc.
   2. Description: Manufacturer's proprietary design to provide at least 99 percent combustion efficiency at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.
   3. Storage-Tank Construction: ASME-code steel with 150 psig minimum working-pressure rating.
      a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
         1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
      b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      c. Lining: Tank lining complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
   4. Factory-Installed, Storage-Tank Appurtenances:
      a. Anode Rod: Replaceable magnesium.
      b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
      c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
      d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
      e. Jacket: Steel with enameled finish.
      f. Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
   5. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for natural-gas fuel.
   6. Temperature Control: Adjustable thermostat.
   7. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.

2.3 COMPRESSION TANKS

A. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
   1. Available Manufacturers:
      a. AMTROL Inc.

b. Armstrong Pumps, Inc.
c. State Industries, Inc.
d. Taco, Inc.
e. Watts Regulator Co.

2. Construction:
   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.

2.4 WATER HEATER ACCESSORIES

A. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.

B. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.

C. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.

D. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

E. Drain Pans: Corrosion-resistant metal with raised edge. Provide dimensions not less than base of water heater and include drain outlet not less than NPS 3/4.

F. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.
   1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

PART 3 - EXECUTION

3.1 WATER HEATER SYSTEM INSTALLATION

A. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

B. Install gas water heaters according to NFPA 54 and International Fuel Gas Code.
   1. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.
   2. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.

3. Install automatic gas valves on gas supplies to gas fired water heaters, if required for operation of safety control.

C. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial, water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install gas shutoff valves on gas supplies to gas fired water heaters without shutoff valves.

E. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains.

F. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

G. Fill water heaters with water.

H. Charge compression tanks with air.

3.2 CONNECTIONS

A. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

B. Piping installation requirements are specified in other related Sections. Drawings indicate general arrangement of piping, fittings and specialties.

C. Ground equipment and connect wiring per Division 26.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:
1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

END OF SECTION

SECTION 22 40 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:
   1. Service Sinks.

1.3 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

C. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities" for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
   2. Plastic Lavatories: ANSI Z124.3.
   3. Plastic Mop-Service Basins: ANSI Z124.6.
   4. Plastic Shower Enclosures: ANSI Z124.2.
   5. Plastic Sinks: ANSI Z124.6.
   6. Plastic Urinal Fixtures: ANSI Z124.9.
   7. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
   8. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
   9. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
   10. Stainless-Steel Residential Sinks: ASME A112.19.3.
   11. Vitreous-China Fixtures: ASME A112.19.2M.
   12. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
   13. Water-Closet, Flushometer Tank Trim: ASSE 1037.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
   2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
   3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
   4. Faucets: ASME A112.18.1.
   5. Hose-Connection Vacuum Breakers: ASSE 1011.
   6. Hose-Coupling Threads: ASME B1.20.7.
   7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
   8. NSF Potable-Water Materials: NSF 61.
   9. Pipe Threads: ASME B1.20.1.
   10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
   11. Supply Fittings: ASME A112.18.1.
   12. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
   1. Atmospheric Vacuum Breakers: ASSE 1001.
   2. Brass and Copper Supplies: ASME A112.18.1.
   3. Dishwasher Air-Gap Fittings: ASSE 1021.
   4. Manual-Operation Flushometers: ASSE 1037.
   5. Plastic Tubular Fittings: ASTM F 409.
   6. Brass Waste Fittings: ASME A112.18.2.
   7. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   1. Disposers: ASSE 1008 and UL 430.
   2. Dishwasher Air-Gap Fittings: ASSE 1021.

3. Flexible Water Connectors: ASME A112.18.6.
4. Floor Drains: ASME A112.6.3.
5. Grab Bars: ASTM F 446.
6. Hose-Coupling Threads: ASME B1.20.7.
7. Hot-Water Dispensers: ASSE 1023 and UL 499.
8. Off-Floor Fixture Supports: ASME A112.6.1M.
9. Pipe Threads: ASME B1.20.1.
10. Plastic Shower Receptors: ANSI Z124.2.
11. Plastic Toilet Seats: ANSI Z124.5.
12. Supply and Drain Protective Shielding Guards: ICC A117.1.
13. Whirlpool Bathtub Equipment: UL 1795.

1.5 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures of unit shell.
      b. Faulty operation of controls, blowers, pumps, heaters, and timers.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   2. Warranty Period for Commercial Applications: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SERVICE BASIN/SINK

A. Service Basin/Sinks:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Acorn Engineering Company.
      b. Crane Plumbing, L.L.C./Fiat Products.
      c. Florestone Products Co., Inc.
      d. Fiat
      e. Stern-Williams Co., Inc.
      f. Mustee, E. L. & Sons, Inc.
   2. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with rim guard. See Plumbing Fixture Schedule on Drawing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install fixtures level and plumb according to roughing-in drawings.

C. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
   1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Section 230523 "General-Duty Valves for Plumbing Piping."

D. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

E. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

F. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

G. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

H. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Section 230500 "Common Work Results for Plumbing and HVAC."

I. Set service basins in leveling bed of cement grout. Grout is specified in Section 230500 "Common Work Results for Plumbing and HVAC."

J. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other related Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
   1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
   2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

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SECTION 22 45 00
EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following emergency plumbing fixtures:
   1. Combination units, eyewash and shower.
   2. Water-tempering equipment.

1.3 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. PVC: Polyvinyl chloride plastic.

D. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.

E. Tepid: Approximately 85 deg F temperature.
   1. Allowable Variation: Plus or minus 5 deg F.

1.4 SUBMITTALS

A. Product Data: Include flow rates and capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each product indicated.

B. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Maintenance Data: For emergency plumbing fixtures to include in maintenance manuals specified in Division 01 33 20.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; about plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in U.S. Architectural & Transportation Barriers Compliance Board's "Uniform Federal Accessibility Standards (UFAS), 1985-494-187" about plumbing fixtures for people with disabilities.

E. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

F. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

1.6 COORDINATION

A. Coordinate roughing-in and final plumbing fixture locations, and verify that fixtures can be installed to comply with original design and referenced standards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. For fixture descriptions in other Part 2 articles where the subparagraph titles "Available Products" and "Products" introduce a list of manufacturers and their products, the following requirements apply for product selection:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products specified in other Part 2 articles.

2.2 COMBINATION UNITS

A. Combination Units: Plumbed, freestanding type with emergency shower and eye/face wash equipment.
   1. Available Products:
      a. Bradley Corporation.
      b. Chicago Faucet Co.
      c. Encon Safety Products.
      d. Guardian Equipment Co.
      e. Haws Corporation.
      f. Lab Safety Supply, Inc.
      g. Murdock, Inc.
      h. Speakman Co.
      i. WaterSaver Faucet Co.
      j. Western Emergency Equipment.

2. See Plumbing Fixture schedule on drawings.

2.3 WATER-TEMPERING EQUIPMENT

A. Hot and Cold-Water-Tempering Equipment: Factory-fabricated equipment including water thermostatic mixing valve designed to provide 85 deg F potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, corrosion-resistant metal piping, and enclosure.
1. Available Products:
a. Bradley Corporation.
b. Encon Safety Products.
c. Haws Corporation.
d. Lawler Manufacturing Co., Inc.
e. Leonard Valve Co.
f. Speakman Co.
g. Western Emergency Equipment.

2.4 SOURCE QUALITY CONTROL

A. Certify performance of plumbed emergency plumbing fixtures by independent testing agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components according to manufacturer's written instructions.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Refer to Section 230523 "General-Duty Valves for Plumbing Piping" for general-duty shutoff valves.
1. Exception: Omit shutoff valves on supplies to emergency equipment if prohibited by authorities having jurisdiction.

E. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping.

F. Install dielectric fitting in supply piping to fixture if piping and fixture connections are made of different metals. Refer to Section 230500 "Common Work Results for Plumbing and HVAC" for dielectric fittings.

G. Install trap and waste to wall on drain outlet of fixture receptors that are indicated to be directly connected to drainage system.

H. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Refer to Section 230500 "Common Work Results for Plumbing and HVAC" for escutcheons.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other related Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot and cold-water-supply piping to hot- and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.

C. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary or storm drainage piping.

3.4 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities and temperatures.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

C. Report test results in writing.

3.5 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION

DIVISION 23
HVAC

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SECTION 23 05 00
COMMON WORK RESULTS FOR PLUMBING AND HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Record Documents, Maintenance Manuals, and General Provisions for Plumbing and HVAC work.
   2. Piping materials and installation instructions common to most piping systems.
   3. Transition fittings.
   4. Dielectric fittings.
   5. Mechanical sleeve seals.
   6. Sleeves.
   7. Escutcheons.
   8. Equipment installation requirements common to equipment sections.
   9. Painting and finishing.
   10. Supports and anchorages.

1.3 SUBMITTALS

A. Product Data: For the following:
   1. Dielectric fittings.
   2. Mechanical sleeve seals.
   3. Escutcheons.

B. Welding certificates.

1.4 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing by the engineer and connecting electrical services, circuit breakers, and conduit

sizes are appropriately modified without added cost to Project. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.5 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces.

1.6 FEES AND PERMITS

A. Contractor shall apply and pay for all permits, inspections, reviews, etc. required by the authorities having jurisdiction.
   1. This shall include the cost of extending the natural gas service from the utility company main line to the building meter, setting the meter and regulator and all related utility company costs.
   2. The Contractor shall include in his/her Bid all system development or similarly named fee imposed by the serving utility company or governing entity (City, County, etc.).

1.7 RECORD DOCUMENTS

A. Prepare Record Documents in accordance with the requirements in Division 01 Section "Closeout Procedures." In addition to the requirements specified in Division 01, indicate the following installed conditions:
   1. Ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units requiring periodic maintenance or repair.
   2. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (ie. traps, strainers, tanks, etc.). Refer to Section 230553 "Identification for Plumbing and HVAC Piping and Equipment". Indicate actual inverts and horizontal locations of underground piping.
   3. Equipment locations (exposed and concealed) dimensioned from prominent building lines.
   4. Approved substitutions, Contract Modifications, and actual equipment and materials installed. Revise equipment schedules.
   5. Contract Modifications, actual equipment and materials installed.

1.8 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 01 Section "Closeout Procedures." In addition to the requirements specified in Division 01. Assemble O & M Manuals as follows:

1. Compile three copies of Operating and Maintenance Manuals for the mechanical systems and equipment. The manuals shall be provided to the Architect for approval complete and at one time, prior to requesting final payment. Partial or separate data will be returned for completion.
2. Manuals shall be assembled in three-ring binders. Binders shall be 3 inches thick or less and more than one binder shall be used for each set of data if required to prevent overfilling of one binder. Binders shall have plastic coating with correct name of the Project permanently attached to the spine. All information shall be arranged in sections and each section shall have a blank buff colored, heavy paper divider with a protruding tab clearly labeled. Sections shall be arranged in the same order that the equipment is listed in the Specification and each Specification Section shall have a separate tab. Shop Drawings which are larger than 8-1/2 inches x 11 inches shall be individually folded so they are 8-1/2 inches x 11 inches or less and inserted behind the appropriate tab.
3. Tabs shall be labeled and arranged as follows:
    a. Index: Furnish under the first tab an index of sections listing name of Section and Specification numbers.
    b. Equipment Manufacturers: Furnish under the second tab a complete typed list of equipment suppliers and manufacturers representative including type of equipment, name, address and phone number. The company listed here should be the one which could furnish replacement parts and offer technical information about the equipment.
    c. Valve Directory: Furnish under this tab a typed copy of the valve chart required.
    d. Product Literature: Each tab, starting with the fourth shall contain the name of a Specification Section. Behind each tab shall be the previously submitted and approved Shop Drawing, factory published operation and maintenance instructions and parts lists.
4. Upon completion and approval of the booklets, one copy shall be given to the Architect, and two to the Owner.
5. Electronic Format: Provide all O&M information in a searchable electronic PDF format on CD for submission to the Owner with the hard copies.

1.9 MECHANICAL EQUIPMENT TRAINING

A. The mechanical contractor shall schedule training with the Owner. Using the O & M Manuals, the mechanical contractor shall explain in detail and instruct the Owner's maintenance personnel in the correct operation and maintenance of the equipment.
    1. The mechanical contractor shall develop and create an agenda to be used during Training.
    2. The mechanical contractor shall provide a sign in sheet to verify dates and types of training and who attended.

B. Refer to specific training and demonstration, Section 01 91 14 requirements in the individual specifications.

1.10 GENERAL PROVISIONS FOR MECHANICAL WORK

A. Interferences: Project design took into account potential interferences between trades (e.g. mechanical ductwork with piping or with electrical light fixtures), however, not every interference has been eliminated. It shall be the responsibility of the Bidder and potential Contractor to field verify all mechanical piping and duct routing, making allowances for existing beams, pipes, ducts, hangers, and other obstructions. Provide HVAC duct offsets and transitions as required maintaining duct aspect ratios within 10 percent of design and piping offsets as required. The cost associated with interferences shall be included in the Base Bid.

B. Examination of Project Drawings:
   1. The Drawings (Plans, elevations, flow schematics, etc.) for the mechanical work are intended to convey Scope of Work and to indicate the general arrangements and locations of end-use equipment, systems, etc., and the approximate sizes thereof.
   2. The Contractor shall determine the exact location and mounting heights of equipment, rough-ins, and the exact routing and positioning of piping/ductwork equipment so as to best fit the layout of the job. Scaling of the Drawings will not be sufficient for determining these locations. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made, by the Contractor, at no additional cost to the Client.
   3. Because of the scale of the Drawings, certain basic items/materials and quantities thereof, (e.g. fittings, connectors, flanges, unions, pipe wells, couplings, hangers, sleeves, clamps, screws, hooks, inserts, pipe/duct mounted - meters, gauges, sensors, etc.) may not be shown, but where such items are required by other sections of the Specifications or where they are required for proper installation of the Work, such items shall be furnished and installed and the cost thereof, reflected in the Base Bid.
   4. The determination of quantities of HVAC and plumbing end-use systems and equipment required shall be made by the Contractor from the Drawings. Interferences and quantities and locations of basic items/materials may not be indicated on the Drawings and will require field verification and determination by the Contractor.
   5. The Contractor shall coordinate the location and method of support of the piping/duct systems with that of all installations under other Divisions and Sections of the Specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 and 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 and 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   2. AWWA C110, rubber, flat face, 1/8-inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BcuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:
   1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   2. PVC to ABS Piping Transition: ASTM D 3138.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
   1. Available Manufacturers:
      a. Eslon Thermoplastics.

B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
   1. Available Manufacturers:
      a. Thompson Plastics, Inc.

C. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
   1. Available Manufacturers:
      a. NIBCO INC.
      b. NIBCO, Inc.; Chemtrol Div.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250 psig minimum working pressure at 180 deg F.
   1. Available Manufacturers:
      a. Central Plastics Company.
      b. Epco Sales, Inc.
      c. Hart Industries, International, Inc.
      d. Watts Industries, Inc., Water Products Div.
      e. Zurn Industries, Inc., Wilkins Div.

D. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300 psig minimum working pressure at 225 deg F.
   1. Available Manufacturers:
      a. Calpico, Inc.
      b. Lochinvar Corp.

E. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300 psig minimum working pressure at 225 deg F.
   1. Available Manufacturers:
      a. Perfection Corp.
      b. Precision Plumbing Products, Inc.
      c. Sioux Chief Manufacturing Co., Inc.
      d. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Available Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.
   2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Plastic or carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
1. One-Piece, Cast-Brass Type: With set screw and polished chrome-plated.

C. Split-Plate, Cast-Brass or Stamped-Steel Type: With concealed hinge, spring clips and chrome-plated finish.

D. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Drawing Plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   1. New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type with spring clips.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast-brass type with polished chrome-plated finish.
      f. Bare Piping in Unfinished Service Spaces: Split plate, cast-brass or stamped steel type with polished chrome-plated finish.

L. Sleeves are not required for core-drilled holes.

M. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Steel Sheet Sleeves: For pipes NPS 6 and larger.
      c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
   4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint.

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

END OF SECTION

SECTION 23 05 29
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Equipment supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For multiple piping supports and trapeze hangers, show fabrication and installation details and include calculations. Details shall indicate connections to equipment, piping and structure.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Thermal-Hanger shield inserts shall be installed at the time of hanger installation.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.
      c. Flex-Strut Inc.
      d. GS Metals Corp.
      e. Thomas & Betts Corporation.
      f. Unistrut Corporation; Tyco International, Ltd.
      g. Wesanco, Inc.
   2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
   3. Standard: MFMA-4.
   4. Channels: Continuous slotted steel channel with inturned lips.
   5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
   7. Metallic Coating: Electroplated zinc.
   8. Paint Coating: Acrylic.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Carpenter & Paterson, Inc.
   2. ERICO International Corporation.
   3. Mechanical Pipe Shields "SNAP-ITZ."
   4. National Pipe Hanger Corporation.
   5. PHS Industries, Inc.
   6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
   7. Piping Technology & Products, Inc.
   8. Rilco Manufacturing Co., Inc.
   9. TOLCO a brand of Nibco.
   10. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig or water-repellent treated, ASTM C 533, Type I calcium silicate, minimum compressive strength and vapor barrier.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.7 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Installed by Mechanical Contractor at time of hanger installation. Inserts are required on all cold piping 2 inch (50 mm) and larger.

E. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before

concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:
1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert for pipes 2 inches and larger. Run insulation continuously through hanger and install a galvanized Type 40 insulation shield between hanger and insulation for pipes smaller than 2 inches .
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Where indicated, install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier smaller than 2 inches. Shields shall span an arc of 180 degrees.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods.

3.5 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for cold insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

Pipe Size	Pipe Material	MSS Hanger Type	Manufacturer/Model	Notes
1/2" - 4"	Bare Steel	Type 1	ANVIL Fig. 65	
5" - 14"	Bare Steel	Type 1	ANVIL Fig. 260	

1/2" - 4"	Bare Copper	Type 9	ANVIL Fig. CT-99 or CT-65	
1/2" - 4"	Insulated Copper (Hot)	Type 9	ANVIL Fig. CT-99 or CT-65	
1/2" - 12"	Insulated Steel (Hot)	Type 1	ANVIL Fig. 300	Hanger may contact pipe.
1/2" - 1-1-2"	Insulated Copper and Steel (Cold)	Type 1	ANVIL Fig. 300 with shield	No pipe contact allowed.
2" - 12"	Insulated Copper and Steel (Cold)	Type 1	ANVIL Fig. 300 with shield and insert	No pipe contact allowed.
2" - 8"	Cast Iron Sewer	Type 1	ANVIL Fig. 260	
1/2" - 4"	Bare PVC	Type 1	ANVIL Fig. 65 Epoxy Coated	
5" - 18"	Bare PVC	Type 1	ANVIL Fib. 260 (Epoxy Coated)	

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
   2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
   3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
   4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
   5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
   3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
13. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
14. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 23 05 53
IDENTIFICATION FOR PLUMBING AND HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:
   1. Equipment markers.
   2. Pipe markers.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
   1. Terminology: Match schedules as closely as possible.
   2. Data:
      a. Name and plan number.
      b. Equipment service.
      c. Design capacity.
      d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.

2.2 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
   1. Colors: Comply with ASME A13.1, unless otherwise indicated.
   2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
   3. Pipes with OD, Including Insulation, Less Than 6 inches: Full-band pipe markers extending 360 degrees around pipe at each location.
   4. Pipes with OD, Including Insulation, 6 inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
   5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils thick with pressure-sensitive, permanent-type, self-adhesive back.
   1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 inches: 3/4-inch minimum.
   2. Width for Markers on Pipes with OD, Including Insulation, 6 inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other related Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment.
   1. Letter Size: Minimum 1/4-inch for name of units if viewing distance is less than 24 inches, 1/2-inch for viewing distances up to 72 inches, and proportionately larger

lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
    a. Fire department hose valves and hose stations.
    b. Fuel-burning units, including boilers, furnaces, heaters, and rooftop units.
    c. Pumps, compressors, chillers, condensers, and similar motor-driven units.
    d. Heat exchangers, cooling towers, heat recovery units, and similar equipment.
    e. Fans, blowers, mixing boxes and VAV boxes.
    f. Packaged HVAC central-station air handling units.
    g. Tanks and pressure vessels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.
    1. Pipes with OD, Including Insulation, Less Than 6 inches: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 3/4-inch wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.
    2. Pipes with OD, Including Insulation, 6 inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.

B. Locate pipe markers where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; exterior nonconcealed locations and concealed ceiling spaces as follows:
    1. Near each valve and control device.
    2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
    3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.
    4. At access doors, manholes, and similar access points that permit view of concealed piping.
    5. Near major equipment items and other points of origination and termination.
    6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
    7. On piping above removable acoustical ceilings at intervals of 50 feet.

3.4 CLEANING

A. Clean faces of mechanical identification devices.

END OF SECTION

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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes TAB to produce design objectives for all air systems.

1.3 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 45 days from Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3.

C. Sample Report Forms: Submit two sets of sample TAB report forms.

1.4 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.

B. The Test and Balance Contractor shall be an independent consultant. The firm shall be independent of all Contractors including the Mechanical and Temperature Controls Contractor.

C. TAB Conference: Meet with Owner's and Engineer's representatives to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.
   1. Agenda Items: Include at least the following:
      a. Submittal distribution requirements.
      b. The Contract Documents examination report.
      c. TAB plan.
      d. Work schedule and Project-site access requirements.
      e. Coordination and cooperation of trades and subcontractors.
      f. Coordination of documentation and communication flow.

D. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

E. TAB Report Forms: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems." Or from SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing."

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.5 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

PART 2 - EXECUTION

2.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

C. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

D. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

E. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

F. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

G. Examine heating water system pumps to ensure absence of entrained air in the suction piping.

H. Examine equipment for installation and for properly operating safety interlocks and controls.

I. Examine operating safety interlocks and controls on HVAC equipment.

J. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

2.2 PREPARATION

A. Complete system readiness checks and submit a system readiness report to the Project Engineer. Verify the following:
1. Permanent electrical power wiring is complete.
2. Automatic temperature-control systems are operational.
3. Equipment and duct access doors are securely closed.
4. Clean filters are installed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors are installed and can be closed so indicated conditions for system operations can be met.
9. Verify leakage and pressure tests on heating water distribution systems have been satisfactorily completed.

2.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

2.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

C. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

D. Verify that motor starters are equipped with properly sized thermal protection.

E. Check dampers for proper position to achieve desired airflow path.

F. Check for airflow blockages.

G. Check condensate drains for proper connections and functioning.

H. Check for proper sealing of air-handling unit components.

I. Check for proper sealing of air duct system.

2.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
   1. Measure total airflow.
      a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
      b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
      c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
      d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

   2. Measure fan static pressures as follows:
      a. Measure static pressure directly at the fan outlet or through the flexible connection.
      b. Measure static pressure directly at the fan inlet or through the flexible connection.
      c. Measure static pressure across each component that makes up the air-handling system.
      d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Construction Manager for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

2.6 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
2. Air Outlets and Inlets: 0 to minus 5 percent.

2.7 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed by the testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.

C. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
   1. Title page.
   2. Name and address of TAB firm.
   3. Project name.
   4. Project location.
   5. Architect's/Engineer's name and address.
   6. Contractor's name and address.
   7. Report date.
   8. Signature of TAB firm who certifies the report.
   9. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   10. Summary of contents including the following:
      a. Indicated versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.
   11. Notes to explain why certain final data in the body of reports varies from indicated values.
   12. Test conditions for fans performance forms including the following:
      a. Settings for outside-, return-, and exhaust-air dampers.
      b. Conditions of filters.
      c. Cooling coil, wet- and dry-bulb conditions.
      d. Fan drive settings including settings and percentage of maximum pitch diameter.
      e. Other system operating conditions that affect performance.

2.8 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION

SECTION 23 07 00
PLUMBING AND HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe, duct, and equipment insulation.

1.2 SUBMITTALS

A. Product data for each type of mechanical insulation identifying k-value, thickness, jackets (factory and field applied) and accessories.

1.3 QUALITY ASSURANCE

A. Fire Performance Characteristics: Conform to the following characteristics for insulation including facings, cements, and adhesives, when tested according to ASTM E 84, by UL or other testing or inspecting organization acceptable to the authority having jurisdiction. Label insulation with appropriate markings of testing laboratory.
   1. Interior Insulation: Flame spread rating of 25 or less and a smoke developed rating of 50 or less.
   2. Exterior Insulation: Flame spread rating of 75 or less and a smoke developed rating of 150 or less.

1.4 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for Plumbing and HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct installation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation.

1.5 SEQUENCING AND SCHEDULING

A. Schedule insulation application after pressure testing of piping and duct systems.

B. Thermal-hanger shield inserts are specified in "Hangers and Supports." Inserts shall be installed at the time of hanger installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. Glass Fiber:
      a. CertainTeed Corporation.
      b. Knauf Fiberglass.
      c. Manville/Schuller.
      d. Owens-Corning Fiberglas Corporation.
      e. E-Insulation.
   2. Flexible Elastomeric Cellular:
      a. Armacell LLC.
      b. IMCOA Corporation.
      c. Rubatex Corporation.

2.2 GLASS FIBER

A. Material: Inorganic glass fibers, bonded with a thermosetting resin.

B. Jacket: All-service, factory-applied, laminated glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil skrim backing having pressure sensitive self-sealing lap.

C. Board: ASTM C 612, Class 2, semi-rigid jacketed board.
   1. Thermal Conductivity: 0.23 average maximum, at 75 deg F mean temperature.
   2. Density: 3.0 pcf average maximum.

D. Blanket: ASTM C 553, Type I, Class B-2, jacketed flexible blankets.
   1. Thermal Conductivity: 0.27 at compressed thickness, at 75 deg F mean temperature.
   2. Density: 0.75lb/cu. ft.

E. Preformed Pipe Insulation: ASTM C 547, Class 1, rigid pipe insulation, factory applied all-service jacket with self seal lap.
   1. Thermal Conductivity: 0.26 average maximum at 75 deg F mean temperature.
   2. Density: 5 lb/cu. ft average maximum.

F. Vapor Barrier Coating: Waterproof coating recommended by insulation manufacturer for outside service.

2.3 FLEXIBLE ELASTOMERIC CELLULAR

A. Material: Flexible expanded closed-cell structure with smooth skin on both sides.
   1. Tubular Materials: ASTM C 534, Type I.
   2. Sheet Materials: ASTM C 534, Type II.

B. Thermal Conductivity: 0.25 average maximum at 75 deg F.

C. Coating: Water based latex enamel coating recommended by insulation manufacturer.

2.4 ADHESIVES

A. Flexible Elastomeric Cellular Insulation Adhesive: Solvent-based, contact adhesive recommended by insulation manufacturer. Comply with MIL-A-24179A, Type II, Class 1.

2.5 FIELD APPLIED JACKETS

A. PVC Jacketing: High-impact, ultra-violet-resistant PVC, 30-mils thick, roll stock ready for shop or field cutting and forming to indicated sizes.
   1. Mastic/Adhesive: As recommended by insulation manufacturer.

B. PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil-thick, high-impact, ultra-violet-resistant PVC.
   1. Mastic around fitting to pipe insulation.

C. Aluminum Jacket: ASTM B 209, 3003 Alloy, H-14 temper, roll stock ready for shop or field cutting and forming to indicated sizes.
   1. Finish and Thickness: Smooth finish, 0.016-inch thick for interior applications and 0.020-inch (0.51mm) thick for exterior applications.
   2. Moisture Barrier for Indoor Applications: 1 mil thick, heat-bonded polyethylene and kraft paper.
   3. Moisture Barrier for Outdoor Applications: 3 mil thick, heat-bonded polyethylene and kraft paper.
   4. Elbows: Preformed 45-degree and 90-degree, short- and long-radius elbows, same material, finish, and thickness as jacket.

2.6 ACCESSORIES AND ATTACHMENTS

A. Bands: 3/4-inch wide, in one of the following materials compatible with jacket:
   1. Aluminum: 0.007-inch thick.
   2. 1/8-inch by 1/8-inch Rapid Penetrating point screws for non vapor barrier application.

B. Wire: 14 gauge nickel copper alloy, 16 gauge, soft-annealed stainless steel, or 160 gauge, soft-annealed galvanized steel.

C. Cupped Head Weld Pins- 1-1/2 inch diameter cupped head, mild, annealed steel with zinc plating.

D. Corner Angles: 28 gauge, 1 inch by 1 inch aluminum, adhered to 2 inch by 2 inch kraft paper.

E. Anchor Pins: Capable of supporting 20 pounds each. Provide anchor pins and speed washers of sizes and diameters as recommended by the manufacturer for insulation type and thickness.

F. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136 and UL listed.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.

5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

G. Foil/Skrim/Kraft Tape: Vapor barrier tape with rubber adhesive and UL listed and 25/20 rated.
1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 85 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 45 lbf/inch in width.

2.7 SEALING COMPOUNDS-MASTIC

A. Vapor Barrier Compound: Water-based, fire-resistive composition.
1. Water Vapor Permeance: 0.08 perm maximum.
2. Temperature Range: Minus 20 to 180 deg F.

B. Weatherproof Sealant: Flexible-elastomer-based, vapor-barrier sealant designed to seal metal joints.
1. Water Vapor Permeance: 0.02 perm maximum.
2. Temperature Range: Minus 50 to 250 deg F.
3. Color: Aluminum.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean, dry, and remove foreign materials such as rust, scale, and dirt.

3.2 INSTALLATION, GENERAL

A. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each mechanical system.

B. Select accessories compatible with materials suitable for the service. Select accessories that do not corrode, soften, or otherwise attack the insulation or jacket in either the wet or dry state.

C. Install vapor barriers on insulated pipes, ducts, and equipment where indicated and defined in insulation service chart.

D. Apply insulation material, accessories, and finishes according to the manufacturer's printed instructions.

E. Seal joints and seams to maintain vapor barrier on insulation requiring a vapor barrier.

F. Seal penetrations for hangers, supports, anchors, and other projections in insulation requiring a vapor barrier.

G. Keep insulation materials dry during application and finishing.

H. Items Not Insulated: Unless otherwise indicated do not apply insulation to the following systems, materials, and equipment:
   1. Metal ducts with duct liner.
   2. Flexible connectors for ducts and pipes.
   3. Testing laboratory labels and stamps.
   4. Nameplates and data plates.
   5. Access panels and doors in air distribution systems.
   6. Chrome-plated pipes and fittings, except for plumbing fixtures for the disabled.
   7. Backflow prevention device.

3.3 PIPE INSULATION INSTALLATION, GENERAL

A. Tightly butt longitudinal seams and end joints.

B. Apply insulation continuously over fittings, valves, and specialties.

C. Apply insulation with a minimum number of joints.

D. Apply insulation with all service jackets as follows:
   1. Pull jacket tight and smooth.
   2. Cover circumferential joints with butt strips, at least 3 inches wide, and of same material as insulation jacket.
   3. Longitudinal Seams: Overlap seams at least 1-1/2-inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap.
   4. At penetrations in jackets for thermometers and pressure gauges, fill and seal voids with mastic.
   5. Repair damaged insulation jackets, except metal jackets, by applying jacket material around damaged jacket. Extend patch at least 2 inches in both directions beyond damaged insulation jacket and around the entire circumference of the pipe.

E. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 2 inches below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.

F. Exterior Wall Penetrations: For penetrations of below grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor barrier coating.

G. Interior Walls and Partitions Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

H. Fire-Rated Walls and Partitions Penetrations: Terminate insulation at penetrations through fire-rated walls and partitions. Seal insulation ends with vapor barrier coating. Seal around penetration with firestopping or fire-resistant joint sealer.

I. Floor Penetrations: Terminate insulation underside of floor assembly and at floor support at top of floor.

J. Flanges, Fittings, and Valves - Interior Exposed and Concealed: Coat pipe insulation ends with mastic. Apply premolded, precut, or field-fabricated segments of insulation around flanges, unions, valves, and fittings. Make joints tight.
1. Use same material and thickness as adjacent pipe insulation.
2. Overlap nesting insulation by 2 inches or 1-pipe diameter, which ever is greater.
3. Insulate elbows with blanket insulation inserts.
4. Cover insulation, except for metal jacketed insulation, with PVC fitting covers and seal circumferential joints with butt strips.

K. Hangers and Anchors: Apply insulation continuously through hangers and around anchor attachments. For vapor barrier application piping, extend insulation on anchor legs a minimum of 12 inches and taper and seal insulation ends.
1. Install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer. Refer to "Hangers and Supports" for thermal-hanger shield inserts.
2. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

3.4 GLASS FIBER PIPE INSULATION INSTALLATION

A. Seal exposed seams and joint ends, with mastic.

3.5 FLEXIBLE ELASTOMERIC PIPE INSULATION INSTALLATION

A. Slip insulation on the pipe before making connections wherever possible. Seal joints with adhesive. Where the slip-on technique is not possible, use longitudinally precut insulation and apply to the pipe. Seal seams and joints with adhesive.

B. Valves, Fittings, and Flanges: Cut insulation segments from pipe or sheet insulation. Bond to valve, fitting, and flange and seal joints with adhesive. Use prefabricated fittings if available.
1. Miter cut materials to cover soldered elbows and tees.
2. Fabricate sleeve fitting covers from flexible elastomeric cellular insulation for screwed valves, fittings, and specialties. Miter cut materials. Overlap adjoining pipe insulation.

3.6 EQUIPMENT INSULATION INSTALLATION, GENERAL

A. Install board materials with a minimum number of joints.

B. Ensure insulation materials to fit as closely as possible to the equipment and to fit contours of equipment. Stagger end joints.

C. Insulation Thicknesses Greater than 2 inches: Install insulation in multiple layers with staggered joints.

D. Secure sections of insulation in place with bands spaced at 12 inch centers, except for flexible elastomeric cellular insulation.

E. Protect exposed corners with corner angles under bands.

F. Manholes, Handholes, and Information Plates: Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

G. Removable Insulation: Install insulation on components that require periodic inspecting, cleaning, and repairing for easy removal and replacement without damage to adjacent insulation.

H. Finishing: Except for flexible elastomeric cellular insulation, see Insulation schedule for jacketing.

3.7 GLASS FIBER EQUIPMENT INSULATION INSTALLATION

A. Secure insulation with anchor pins and speed washers.

B. Space anchors at maximum intervals of 18 inches in both directions and not more than 3 inches from edges and joints.

3.8 FLEXIBLE ELASTOMERIC EQUIPMENT INSULATION INSTALLATION

A. Install sheets of the largest manageable size.

B. Apply full coverage of adhesive to the surfaces of the equipment and to the insulation.

C. Butt insulation joints firmly together and apply adhesive to insulation edges at joints.

D. Coat exterior installations with manufacturer’s coating and install by manufacturer's installation instructions.

3.9 FIELD APPLIED JACKETS

A. Install metal jacket with 2 inch overlap at longitudinal and butt joints. Overlap longitudinal joints to shed water. Seal butt joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel draw bands 12 inches on center and at butt joints.

B. Install the PVC jacket with 1 inch overlap at longitudinal and butt joints and seal with adhesive.

3.10 FINISHES

A. Flexible Elastomeric Cellular Insulation: After adhesive has fully cured, apply 2 coats of manufacturer's recommended protective coating to exposed insulation.

B. Exterior insulated ductwork and equipment shall have a weatherproof coating applied over the insulation.

3.11 INSULATION SCHEDULES

A. General: Abbreviations used in the following schedules include:
   1. Field-Applied Jackets: PVC - PVC, A - Aluminum, SS - Stainless Steel, Glass Cloth.
   2. Pipe Sizes: NPS - Nominal Pipe Size.
   3. Materials: GF - Glass Fiber, FE - Flexible Elastomeric.

B. Pipe Insulation:

APPLICATION	TEMP (°F)	NOM. PIPE SIZE (IN.)	INSUL. MAT.	THICK NESS (IN.)	INSERTS OR SHIELDS NOTE 1	VAPOR BARRIER	FIELD APP. JKT.
DOMESTIC COLD WATER	ALL	ALL	GF OR FE	1	NO	YES	NONE
DOMESTIC HOT WATER	ALL	1/2 TO 1 1/4 1 1/2 TO 4	GF OR FE	1 1.5	NO	NO	NONE
EVAP COOLER MAKEUP WATER, RECIRC PUMP AND PIPING, CHEMICAL FEED LINES, BELOW DOWN AND DRAIN PIPING	ALL	ALL	GF or FE	1	YES	PVC OR A	PVC OR A
PLUMBING VENTS WITHIN 6 FT OF ROOF OUTLET	ALL	ALL	GF	1	NO	NO	NONE
REFRIGERANT SUCTION AND HOT GAS	ALL	BELOW 1 1 AND UP	FE FE	1/2 1	NO	NO	NONE
RAIN WATER AND OVERFLOW	ALL	ALL	GF OR FE	1	NO	NO	NONE

DOMESTIC HOT WATER AND HW RECIRC	ALL	< 1-1/2	GF OR FE	1	NO	NO	NONE

NOTE 1: INSERTS AND SHIELDS ARE IN SECTION 230529 - HANGERS AND SUPPORTS FOR PLUMBING AND HVAC PIPING AND EQUIPMENT AND SHALL BE PROVIDED BY THE INSULATION CONTRACTOR.

NOTE 2: ALL PIPING INSTALLED OUTDOORS OR EXPOSED TO WEATHER SHALL HAVE FIELD APPLIED JACKET, EVEN IF A JACKET IS NOT EXPICITLY CALLED OUT IN TABLE.

END OF SECTION

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SECTION 23 09 00
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control equipment for the HVAC systems and components, including control components for equipment that is not supplied with factory-wired controls.

B. Control Sequence is defined on Drawing H-05 as the manner and method by which controls function. Requirements for each type of equipment control system operation are specified on this drawing.

1.3 CONTROL SYSTEM DESCRIPTION

A. The Temperature Control Contractor work shall consist of the provision of all labor, materials, tools, equipment, interfaces, wiring, installation, submittals, training services, and O&Ms required for a complete commissioned and fully functional control system.

B. The control system shall be as indicated on the drawing and described in the Specifications. The Temperature Control Contractor shall provide hardware, software and programming necessary to implement the functions and control sequence on this project utilizing direct digital control technology.

C. The control system shall be designed such that each mechanical system will be able to operate stand alone control.

1.4 SUBMITTALS

A. Shop Drawings, Product Data, and Samples:
   1. At a minimum, submit the following:
      a. Systems schematics, sequences, and flow diagrams.
      b. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
      c. Product data sheets or marked catalog pages including part number, photo and description for all products including software.

B. Product Data for each type of product specified. Include manufacturer's technical Product Data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, installation instructions, and startup instructions. Provide manufacturer's cut sheets with the data specifically applicable to the project highlighted or clearly indicated and referenced to each Control Drawing.

C. Wiring diagrams detailing wiring for power, signal and control systems and differentiating clearly between manufacturer installed and field installed wiring.

1.5 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals:
1. PDF copies of the Operation and Maintenance (O&M) Manuals shall be provided to the Owner's Representative upon completion of the project. The entire O&M Manual shall be furnished in PDF format and include the following:
a. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
b. Manufacturer's product data sheets or catalog pages for all products

PART 2 - PRODUCTS

2.1 APPROVED CONTRACTORS / MANUFACTURERS

A. Subject to compliance with requirements:
1. DisTech Controls; by Harris Company; Boise, ID
2. Prior approved equal.

2.2 CONTROLLERS

A. Programmable Field Controllers (PFC):
1. The Programmable Field Controller (PFC) shall be a fully programmable digital controller that communicates via BACnet protocol, Distech ECB-253 Controller with Display.
2. The PFC shall accommodate the direct wiring of analog and binary I/O field points.
3. The PFC shall have a local display with Operator display / adjust / override capabilities.
4. The PFC shall support the following types of inputs and outputs:
a. Universal Inputs shall be configured to monitor any of the following:
1) Analog Input, Voltage Mode.
2) Analog Input, Current Mode.
3) Analog Input, Resistive Mode.
4) Binary Input, Dry Contact Maintained Mode.
5) Binary Input, Pulse Counter Mode.
b. Binary Inputs shall be configured to monitor either of the following:
1) Dry Contact Maintained Mode.
2) Pulse Counter Mode.
c. Analog Outputs shall be configured to output either of the following:
1) Analog Output, Voltage Mode.
2) Analog Output, Current Mode.
d. Binary Outputs shall output the following:
1) 24 VAC Triac.

2.3 INPUT DEVICES

A. Temperature Sensors:

1. General Requirements:
    a. Sensors and transmitters shall be provided, as outlined in the sequence of operations.
    b. The temperature sensor shall be of the resistance type RTDs or Thermistors.

2. Room Temperature Sensors:
    a. Room sensors shall be constructed for wall box mounting.
    b. Room sensors shall have the following options:
        1) Stainless steel wall plate with no adjustment or display. Room set point changed from Operator interface only.
        2) Stainless steel wall plate with momentary push-button for timed override request, or custom programming sequence. Room set point changed from Operator interface only.

3. Room Temperature Sensors with Integral Display:
    a. Room sensors shall be constructed for either surface or wall box mounting.
    b. Room sensors shall have an integral LCD display and keypad with the following capabilities:
        1) Display room temperature
        2) Display and adjust room comfort setpoint

4. Outside Air Sensors:
    a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
    b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
    c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

5. Duct Mount Sensors:
    a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
    b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
    c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

B. Status and Safety Switches:
1. Current Sensing Switches:
    a. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
    b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
2. Air Flow Switches:

a. Differential pressure flow switches shall be bellows actuated snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

2.4 OUTPUT DEVICES

A. Actuators:
1. General Requirements:
a. Damper actuators shall be electronic.

B. Control Relays:
1. Control Pilot Relays:
a. SPDT, DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
b. Contacts shall be rated for 10 amps at 120 VAC.
c. Relays shall have an integral indicator light.

2. Control Power Relays:
a. SPDT, DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
b. Contacts shall be rated for the proper resistive, inductive, or motor HP load.
c. Relays shall have an integral indicator light.

2.5 MISCELLANEOUS DEVICES

A. Local Control Panels:
1. Control panels shall be fully enclosed, with perforated sub-panel and hinged door.
2. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth that are not required to be located external to the control panel due to function.
3. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
4. All wiring shall be neatly installed in plastic trays or tie-wrapped.
5. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.

PART 3 - PERFORMANCE / EXECUTION

3.1 ELECTRICAL WIRING AND CONNECTION

A. Provide low voltage wiring, control transformers, and miscellaneous devices required for a complete and functional control system. Include control wiring, conduit, connection between field devices and panel devices, control and equipment panels, control transformers, electrical starter and safety circuit connections and interlock wiring.

B. Install signal and communication cable according to:
1. All conduit, wiring, accessories and wiring connections required for the installation of the Control System including power wiring for all controllers shall be provided by

the TC Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes.

2. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the TC Contractor.
3. Class 2 Wiring: All Class 2 (24 VAC or less) wiring shall be installed in conduit.
4. Class 2 signal wiring and 24 VAC power can be run in the same conduit. Power wiring 90 VAC and greater cannot share the same conduit with Class 2 signal wiring.
5. Locate controls components in local control panels wherever possible.

3.2 TRAINING AND DEMONSTRATION

A. Start, test and adjust controls system.

B. The TC Contractor shall provide the following training services:
   1. On-site training by a System Technician who is fully knowledgeable of the specific installation details of the project shall be performed following substantial completion of the project. This orientation shall, at a minimum, consist of instructions for the control systems operation, review of the project as-built drawings, and a walk through of the facility to identify equipment, panels, and device locations.

END OF SECTION

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SECTION 23 11 23
NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Service Meter.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 65 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: More than 0.5 psig but not more than 10 psig.

1.5 SUBMITTALS

A. Product Data: For each type of the following:

1. Piping specialties.
2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Pressure regulators. Indicate pressure ratings and capacities.
4. Dielectric fittings.

B. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.8 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

B. PE Pipe: ASTM D 2513, SDR 11.

1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

    a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.

b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
c. Aboveground Portion: PE transition fitting.
d. Outlet shall be threaded or flanged or suitable for welded connection.
e. Tracer wire connection.
f. Ultraviolet shield.
g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.

a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
b. Outlet shall be threaded or flanged or suitable for welded connection.
c. Bridging sleeve over mechanical coupling.
d. Factory-connected anode.
e. Tracer wire connection.
f. Ultraviolet shield.
g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

5. Plastic Mechanical Couplings, NPS 1-1/2 and Smaller: Capable of joining PE pipe to PE pipe.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Lyall, R. W. & Company, Inc.
2) Mueller Co.; Gas Products Div.
3) Perfection Corporation; a subsidiary of American Meter Company.

b. PE body with molded-in, stainless-steel support ring.
c. Buna-nitrile seals.
d. Acetal collets.
e. Electro-zinc-plated steel stiffener.

2.2 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.3 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.

4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inch to NPS 2 shall have initials "WOG" permanently marked on valve body.

B. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Lee Brass Company.
   b. McDonald, A. Y. Mfg. Co.
2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 2 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.4 SERVICE METERS

A. Diaphragm-Type Service Meters: Comply with ANSI B109.2.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Actaris.
      b. American Meter Company-Elster Model AC-630
      c. Invensys.
   2. Case: Die-cast aluminum.
   3. Connections: Steel threads.
   4. Diaphragm: Molded, convoluted.
   5. Oil-impregnated, self-lubricating bushings.
   6. Graphite filled phenolic valves to minimize wear.
   7. Low friction, grommet seals.
   8. Compensation: Temperature and pressure compensation from -30F to 140F.
   9. Meter Index: Cubic feet.
   10. Meter Case and Index: Tamper resistant.

11. Maximum Inlet Pressure: 25 psig.
12. Pressure Loss: Maximum 2.0-inch wg.
13. Accuracy: Maximum plus or minus 1.0 percent.

2.5 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Actaris.
    b. American Meter Company.
    c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
    d. Invensys.
    e. Richards Industries; Jordan Valve Div.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig.

C. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Actaris.
b. American Meter Company.
c. Eclipse Combustion, Inc.
d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
e. Invensys.
f. Maxitrol Company.
g. Richards Industries; Jordan Valve Div.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Hart Industries International, Inc.
d. Jomar International Ltd.
e. Matco-Norca, Inc.
f. McDonald, A. Y. Mfg. Co.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
h. Wilkins; a Zurn company.

2. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig minimum at 180 deg F.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.7 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to the NFPA 54 and International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with the NFPA 54 and International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 PAINTING

A. Paint exposed, exterior and interior metal piping, valves, and piping specialties, except components, with field-applied paint or protective coating. See specification section 09 90 00 for coating and painting of natural gas piping.

B. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.4 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

E. Install fittings for changes in direction and branch connections.

F. Install pressure gage downstream from each service regulator.

3.5 INDOOR PIPING INSTALLATION

A. Comply with the NFPA 54 and International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

P. Connect branch piping from top or side of horizontal piping.

Q. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

R. Do not use natural-gas piping as grounding electrode.

S. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

T. Install sleeves for piping penetrations of walls, ceilings, and floors.

U. Install sleeve seals for piping penetrations of concrete walls and slabs.

V. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.6 SERVICE METER ASSEMBLY INSTALLATION

A. Install service-meter assemblies aboveground, on concrete bases.

B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

C. Install strainer on inlet of service-pressure regulator and meter set.

D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.

E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.

F. Install service meters downstream from pressure regulators.

3.7 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing connector.

G. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.
   3. Bronze plug valve.

H. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, nonlubricated plug valve.

I. Valves in branch piping for single appliance shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.
   3. Bronze plug valve.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install anode for metallic valves in underground PE piping.

3.8 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.9 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.

3.10 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.11 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for Plumbing and HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to the NFPA 54 and International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.13 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be one of the following:

1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.

B. Aboveground natural-gas piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 2 PSIG

A. Aboveground, branch and distribution piping, NPS 2 and smaller shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, branch and distribution piping, larger than NPS 2 1/2 shall be one of the following:
1. Steel pipe with steel welding fittings and welded joints.

3.15 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

END OF SECTION 23 11 23

SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Rectangular ducts and fittings.
   2. Single-wall round ducts and fittings.

1.3 DEFINITIONS

A. NUSIG: National Uniform Seismic Installation Guidelines.

1.4 WORK INCLUDED

A. Provide an installed duct system which will supply the air quantities indicated by the Drawings and have the lowest possible friction loss with the least possible leakage loss. System static pressure loss for each system shall not exceed that which is indicated in the equipment schedule as external static pressure or in the fan schedule as static pressure and shall include the losses of all accessories. Friction losses shall be minimized by reduction in the number of offsets and elbows by pre-planning the duct system installation and coordination with other trades to prevent interferences. Maintain access to accessories requiring maintenance, service, and inspection. Radius elbows are preferred for turns to minimize friction, noise, and vibrations, and especially for sections having large volume or higher velocities and sections which may have turbulence.

B. Provide and/or construct materials, ductwork, joints, transformations, splitters, dampers, and access doors as specified herein for the sheet metal ductwork as shown on Drawings.

1.5 SUBMITTALS

A. Shop Drawings:
   1. Ductwork fabrication shop standards.
   2. Fittings.
   3. Reinforcement and spacing.
   4. Seam and joint construction.
   5. Penetrations through fire-rated and other partitions.
   6. Equipment installation based on equipment being used on Project.
   7. Duct accessories, including access doors and panels.
   8. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. NFPA Compliance:
   1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
   2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

B. Joint and Seam Tape: Not acceptable.

C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

D. Water-Based Joint and Seam Sealant: One-part flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

E. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.

F. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

G. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

A. Hanger Materials: Galvanized sheet steel or threaded steel rod.
   1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
   2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
   3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

B. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

C. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.5 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
   1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
   2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
   1. Available Manufacturers:
      a. Ductmate Industries, Inc.
      b. Nexus Inc.
      c. Ward Industries, Inc.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.
   1. Available Manufacturers:
      a. Ductmate Industries, Inc.
      b. Lockformer.

2. Duct Size: Maximum 30 inches wide and up to 2 inch wg pressure class.
3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant (only on all medium and high pressure ductwork).

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 12 inches and larger and 20 gage or less, with more than 10 sq. ft. of nonbraced panel area.

E. Transitions:
1. Do not exceed 1 inch in 7 inches of slope for increase-in-area transitions.
2. Do not exceed 1 inch in 4 inches of slope for decrease-in-area transitions, 1 inch in 7 inches is preferable.
3. Do not exceed 45 degrees on the entering or leaving side for angle of transitions at connections to equipment without the use of approved vanes.

F. Elbows:

1. Fabricate elbows using one of the following Specifications: The fabrication methods are listed in order of preference. Use radius elbows wherever possible. Use square elbows only when available space prevents the use of radius elbows.
   a. Unvaned, long radius elbow with the throat radius equal to 3/4 of the width of the duct and with a full heel radius.
   b. Six inch throat radius with full radius, single thickness vanes and full heel radius.
   c. Square elbows with airfoil, double thickness turning vanes.
   d. Maximum unsupported length of vanes shall be 36 inches. Securely fasten vanes to runners. Secure vanes in stable position. Construct vane edges to project tangents parallel to duct sides.
2. Turning Vanes:
   a. True airfoil design; smoothly-rounded entry nose with extended trailing edge. Generated sound power level shall not exceed 54 decibels in band 4 at 2000 FPM in a 24 inch x 24 inch duct.
   b. Manufacturer: Equal to Aero/Dyne Co., High Efficiency Profile, HEP. Contact Aero/Dyne Co. at 1215 High Street, Suite 103, Auburn, CA 95603. (Telephone #800-522-2423).
   c. Fabricate assemblies with side rails; install vanes on design centers of 2.4 inches across the full diagonal dimension of the elbow.
   d. Submit manufacturer's product data for review.

G. Branch Connections:
1. Pressure Classification 2 Inches and Less:
   a. Rectangular branch from rectangular main: 45 degree entry with all corners closed as shown in Figure 4-6.
   b. Round branches: High-efficiency take-offs.
   c. Parallel flow branches: See Figure 4-5.
   d. Space duct joints to avoid cutting them for branch take offs and outlet collars.

2.6 ROUND DUCT AND FITTING FABRICATION

A. Round and Flat-Oval, Spiral Lock Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
   1. Available Manufacturers:
      a. Accu-Duct.
      b. McGill AirFlow Corporation.
      c. Norlock.
      d. Omniduct.
      e. SEMCO Incorporated.
      f. Team Mechanical Inc.
      g. Ventline.
      h. Sheet Metal Contractors, Inc.

B. Duct Joints:
   1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.

C. 90 Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts. Tees shall be conical. Saddle taps or straight tees shall not be used.

D. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

E. Two piece mitered elbows shall not be used.

F. The leading edge of all vanes in ducts over 20 inch diameter is to be hemmed with 1/2 inch foldback. Turning vanes in ducts over 24 inches are to be reinforced by stays or sectional construction to limit unsupported length to 24 inches. Vanes shall be minimum of 20 gauge.

G. Reduction of divided flow fittings to conical span section in the 36 common reductions in sizes 4 inch through 22 inch.

H. Galvanized areas damaged by welding to be coated with corrosion resistant aluminum paint.

I. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
   1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
   2. 90 Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
   3. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45 and 90 degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only.

Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.

4. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
5. Round Elbows Larger Than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
6. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 20 gage thick with 2-piece welded construction.
7. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
   1. Supply Ducts: 2 inch wg.
   2. Return and Exhaust Ducts (Negative Pressure): 2 inch wg.

B. All ducts shall be galvanized steel.

3.2 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections. Secure fittings with screws. Install screws at intervals of 10 inches, with a minimum of (3) screws per fitting. Seal all joints and seams.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Protect duct interiors with sheet metal or plastic sheet covers from moisture, construction debris and dust, and other foreign materials until system is energized. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines," Intermediate Level.

L. Intermediate duct reinforcement to be same as duct material.

M. Do not exceed 45 degrees for easement transition angle.

N. Insulation: Where Drawings and Specifications require ducts to be insulated, make provisions for neat insulation finish around damper operating quadrants, splitter adjusting clamps, access doors, and similar operating devices. Metal collar equivalent in depth to insulation thickness and of suitable size to which insulation may be finished used for this purpose shall be attached to the duct. Linings in air ducts shall meet the Erosion Test Method described in UL Publication no. 181.

O. Counterflashing: Counterflash ductwork penetrating roof.

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts, anchors, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Powder-actuated fasteners not acceptable for ductwork installation.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Support round ducts from building structure with galvanized steel hangers as recommended in SMACNA manual. Secure hangers to masonry portion of building by means of inserts or other acceptable anchors.

3.4 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes.
   1. Space lateral supports a maximum of 40 feet o.c. and longitudinal supports a maximum of 80 feet o.c.
   2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Set anchors to manufacturer's recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 AIR TEST AND BALANCE

A. Prepare the system for tests as specified in Section 230593 and correct deficiencies found by the Test and Balance firm.

B. Duct dimensions shown on Drawings indicate inside clear dimensions. Make allowances for duct requiring internal sound lining, or insulation to provide "inside clear"(IC) dimensions.

C. In addition to the requirements above, add supplemental bracing as necessary to prevent sagging and drumming, and/or vibration.

END OF SECTION

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SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Backdraft dampers.
   2. Manual volume dampers.
   3. Control Dampers and Damper Actuators.
   4. Flange connectors.
   5. Turning vanes.
   6. Flexible connectors.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
      a. Special fittings.
      b. Manual volume damper installations.
      c. Control damper installations.
      d. Wiring Diagrams: For power, signal, and control wiring.

C. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with AMCA 500-D testing for damper rating.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90.
   2. Exposed-Surface Finish: Mill phosphatized.

C. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT DAMPERS

A. Manufacturers:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. American Warming and Ventilating; a division of Mestek, Inc.
   3. Cesco Products; a division of Mestek, Inc.
   4. Duro Dyne Inc.
   5. Greenheck Fan Corporation.
   6. McGill Airflow Corporation.
   7. Nailor Industries Inc.
   8. Penn Ventilation.
   9. Ruskin Company.
   10. SEMCO Incorporated.
   11. Vent Products Company, Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2000 fpm.

D. Maximum System Pressure: 1-inch wg.

E. Frame: 0.052-inch- thick, galvanized sheet steel, with welded corners and mounting flange.

F. Blades: Multiple single-piece blades, center-pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:
   1. Material: Galvanized steel.

J. Tie Bars and Brackets: Aluminum.

K. Return Spring: Adjustable tension.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Manufacturers:
      a. Air Balance Inc.; a division of Mestek, Inc.
      b. American Warming and Ventilating; a division of Mestek, Inc.
      c. Cesco Products.
      d. Flexmaster U.S.A., Inc.
      e. Greenheck Fan Corporation.
      f. McGill AirFlow LLC.
      g. METALAIRE, Inc.
      h. Nailor Industries Inc.
      i. Penn Ventilation.
      j. Ruskin Company.
      k. Vent Products Company, Inc.
   2. Standard leakage rating, with linkage outside airstream.
   3. Suitable for horizontal or vertical applications.
   4. Frames:
      a. Hat-shaped,galvanized steel channels, 0.064-inch minimum thickness.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   5. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized steel, 0.064 inch thick.
   6. Blade Axles: Galvanized steel.
   7. Bearings:
      a. Oil-impregnated bronze.
      b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   8. Tie Bars and Brackets: Galvanized steel.

2.4 TURNING VANES

A. Manufacturers:
   1. Aerodyne, Inc.
   2. Ductmate Industries, Inc.
   3. Duro Dyne Inc.
   4. METALAIRE, Inc.
   5. SEMCO Incorporated.
   6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set for ducts over 36 inches; set into vane runners suitable for duct mounting.
   1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

D. Vane Construction: Double wall.

E. Install turning vanes in all square and rectangular elbows.

2.5 FLEXIBLE CONNECTORS

A. Available Manufacturers:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. Ventfabrics, Inc.
   4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch- wide, 24 gage thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
   1. Minimum Weight: 26 oz./sq. yd.
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install all control equipment including motorized dampers, valves and actuators according to manufacturer's written installation instructions.

B. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal.

C. Install duct accessories of materials suited to duct materials; use galvanized steel accessories in galvanized ducts.

D. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   2. Elsewhere as indicated.

H. Install access doors with swing against duct static pressure.

I. Access Door Sizes:
   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.
   3. Head and Hand Access: 18 by 10 inches.

J. Label access doors according to Division 23 Section "Identification for Plumbing and HVAC Piping and Equipment" to indicate the purpose of access door.

K. Install flexible connectors to connect ducts to equipment.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Inspect turning vanes for proper and secure installation.

END OF SECTION

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SECTION 23 34 23
HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Centrifugal UpBlast roof ventilators.
   2. Inline Ventilators.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.
   7. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 INLINE VENTILATORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. ACME Engineering and Manufacturing Company.
   2. Carnes Company HVAC.
   3. Loren Cook Company.
   4. Greenheck Fan Corp.

B. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

C. Housing: Steel, lined with acoustical insulation.

D. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

E. Grille: Steel, louvered grille with flange on intake and thumbscrew attachment to fan housing.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

G. Accessories:
   1. Isolation: Rubber-in-shear vibration isolators.
   2. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.2 UPBLAST CENTRIFUGAL ROOF VENTILATORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Acme Engineering and Manufacturing Company.
   2. Carnes Company HVAC.
   3. Loren Cook Company.
   4. New York Blower Company (The).
   5. Penn Ventilation.
   6. Greenheck Fan Corp.

B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and, drive assembly, curb base, and accessories.

C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
   1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   4. Fan and motor isolated from exhaust airstream.

F. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

G. Roof Curbs: Provide curb adapter for fan to sit on existing concrete curb. Coordinate existing size for exhaust fan.

2.3 MOTORS

A. Enclosure Type: Totally enclosed, fan cooled.

2.4 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 230553 "Identification for Plumbing and HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other related Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment and connect wiring according to Electrical Specification.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.
   7. Verify lubrication for bearings and other moving parts.
   8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
   10. Shut unit down and reconnect automatic temperature-control operators.
   11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION

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SECTION 23 37 13
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes diffusers, registers, and grilles for all HVAC systems.

1.3 DEFINITIONS

A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.

B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.

C. Register: A combination grille and damper assembly over an air opening.

1.4 SUBMITTALS

A. Product Data: For each model indicated, include the following:
   1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, color and mounting details. Include materials and methods of assembly.
   2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers' products with equal performance characteristics may be considered.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Anemostat.
2. Tuttle & Bailey.
3. Krueger.
4. METALAIRE, Inc.
5. Nailor Industries.
6. Price Industries.
7. Titus.

2.2 SOURCE QUALITY CONTROL

A. Testing: Test performance according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of the panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connection to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.4 CLEANING

A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION

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SECTION 23 55 33
UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes gas-fired unit heaters.

1.3 SUBMITTALS

A. Product Data: For each type of fuel-fired unit heater indicated. Include rated capacities, operating characteristics, and accessories.

B. Operation and Maintenance Data: For fuel-fired unit heaters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 GAS-FIRED UNIT HEATERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Lennox Industries, Inc.
   2. Modine Manufacturing Company.
   3. Reznor/Thomas & Betts Corporation.
   4. Sterling HVAC Products; Div. of Mestek Technology Inc.
   5. Trane Company (The).

B. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.
   1. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.

2. AGA Approval: Designed and certified by and bearing label of American Gas Association.

C. Type of Venting: outdoor, separated combustion, power vented.

D. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
1. External Casings and Cabinets: Powder coating over corrosion-resistant-treated surface.
2. Finish: Manufacturer's standard paint applied to factory-assembled and tested, fuel-fired unit heater before shipping.

E. Heat Exchanger: Aluminized steel.

F. Burner Material: Aluminized steel with stainless-steel inserts.

G. Unit Fan: Formed-steel propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
1. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
2. Motors: Totally enclosed with internal thermal-overload protection and complying with Division 23 Section "Common Motor Requirements for HVAC Equipment."
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

H. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
1. Gas Control Valve: Two stage
2. Ignition: Electronically controlled electric spark with flame sensor.
3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
4. Control transformer.
5. High Limit: Thermal switch or fuse to stop burner.
6. Thermostat: 2-stage, wall-mounting type with 50 to 90 deg F operating range and fan on switch.

I. Discharge Louvers: Independently adjustable horizontal blades.

J. Accessories:
1. Four-point suspension kit.
2. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.

2.2 LISTED TYPE B AND BW VENTS

A. Available Manufacturers:
1. Hart & Cooley, Inc.
2. Heat-Fab, Inc.
3. Metal-Fab, Inc.

4. Protech Systems, Inc.
5. Schebler, Inc.
6. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
7. Simpson Dura-Vent Co., Inc.; Subsidiary of Simpson Manufacturing Co.
8. Van-Packer Company, Inc.

B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F continuously for Type B, or 550 deg F continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch airspace.

D. Inner Shell: Aluminum alloy or stainless steel.

E. Outer Jacket: Galvanized or aluminized steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect gas-fired unit heaters and associated fuel and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written installation instructions.

B. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
1. Restrain the unit to resist code-required horizontal acceleration.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to fuel-fired unit heater to allow service and maintenance.

C. Gas Piping: Comply with applicable Division 23 Section for fuel gas piping requirements. Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

D. Electrical Connections: Comply with applicable requirements in Division 26 Sections.

1. Install electrical devices furnished with heaters but not specified to be factory mounted.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

C. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

D. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:
   a. Test procedures used.
   b. Test results that comply with requirements.
   c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

END OF SECTION

SECTION 23 76 00
EVAPORATIVE COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes evaporative cooling units.

1.3 SUBMITTALS

A. Product Data: For each type of evaporative cooler indicated. Include the following:
   1. Certified fan-performance curves with system operating conditions indicated.
   2. Certified Evaporative Media-performance ratings with system operating conditions indicated.
   3. Motor ratings, electrical characteristics, and motor and fan accessories.
   4. Material gages and finishes.
   5. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   6. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   7. Control panel layout drawings showing devices, contacts, relays, and starters.

B. Operation and Maintenance Manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One set(s) for each unit.
   2. Fan Belts: One set(s) for each unit.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to the following.
   1. Alton, Mestek Co.
   2. Bessam-aire Inc.
   3. Carrier
   4. Governair div. of CES Group Inc.
   5. Premier Industries
   6. Phoenix Manufacturing Inc.
   7. Spec-Air
   8. United Metal Products

2.2 GENERAL

A. Self-contained, exterior mounted, single housing unit consisting of a minimum of a "wet section" and "fan section". The "wet section" shall consist of cooling media, water delivery system and indicated accessories. The "fan section" shall consist of a blower, motor, drive arrangement and selected accessories to deliver the specified air volumes. The wet section and fan section shall be constructed from 304 grade stainless steel unless specified otherwise.

2.3 HOUSING

A. Fan Housing: The fan section shall be constructed from stainless steel, grade 304 natural 2B bright finish. The entire housing shall be constructed in one piece and supported on a "C" channel type undercarriage frame, with lifting lugs, around the entire perimeter and cross-wise under both the fan and wet sections. The housing shall be airtight and waterproof.
   1. Access Door: A hinged access panel shall be provided at a minimum height of the fan housing or larger. The access panel shall be gasketed or formed to preclude air or water leakage into interior and shall allow service of motor, belt adjustment, bearings and shaft replacement.

B. Wet Section Housing: The wet section shall be constructed from stainless steel, grade 304. It shall consist of a sump with side and roof panels. A hinged panel for media access and service of the float valve assembly shall be provided. Removal and replacement of the media can be made through either a side lift off panel, or top removal. The wet section shall be mechanically attached or welded to the fan section housing and shall be supported across its entire width by the under-carriage frame.

2.4 FAN SECTION

A. Fan: Centrifugal type, double width, double intake, forward curved or backward inclined and shall be capable of delivering air volume at the external static pressure indicated. The fan shall meet AMCA 210 standards and shall be mounted in arrangement 3 configuration. The discharge shall be down as indicated. The fan shall have a solid, ground and polished steel shaft with a lubricated self-aligning type bearing on both ends. Fan sheave shall be non-adjustable v-groove type selected to provide necessary fan RPM. The motor sheave shall be adjustable v-groove type selected to provide the necessary fan RPM. Vibration isolation shall be provided under the fan and motor and shall be the spring type. Isolators

shall be selected for minimum deflection. Flexible neoprene shall be attached between the blower and fan discharge and the cabinet.

B. Motor: Open drip proof (ODP) with 1.15 service factor. Motor mount shall be adjustable to allow for drive belt tension and alignment. Electrical characteristics of motor shall comply with available electrical service.

C. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.

2.5 EVAPORATIVE COOLING MODULE "WET SECTION"

A. Cooling Media: Cooling media shall be rigid media 12" thick, Kuul evaporative media or equal. Media shall be cross-fluted pad of cellulose material impregnated with anti-rot salts, rigidifying saturates and wetting agents with at least 123 square feet of evaporative surface area per cubic foot of media. Media shall have no more than 0.315" w.g. air pressure drop at 500 fpm face velocity and shall develop a saturation efficiency of not less than 90% for 12" thick media.

B. Sump: The sump shall be leak proof without the use of fillers, sealants or coatings and shall have TIG (fusion) welded corners and joints. A media support channel with punched holes in a staggered pattern shall be included. The channel shall extend across the full width of the media and provide a minimum of 50% open area for water to flow from media into the sump. An air bypass inhibitor plate shall be provided from the intake bottom of the media, extending into the water to prevent any untreated airflow under the media. Stainless steel couplers with female pipe thread shall be welded into the sump and side to provide for make-up water, overflow, and drain.

C. Water Distribution System: System shall be a pumped re-circulating system with mechanical float valve assembly to maintain water level in the sump. A bleed-off system with metering valve shall be provided. Bleed-off rate shall be set at 20% of evaporation rate. Pump shall be sized to deliver water flow rate at the head pressure required. Flow rate shall be three times the evaporation rate plus the bleed-off rate. Internal plumbing shall be PVC schedule 40 sized to meet the pump flow rate. A balancing valve shall be provided in the riser pipe between the source and header to regulate water flow over the media. Header pipe shall contain drilled orifice holes sized to assure proper water flow over the media. Water from the header pipe shall be discharged upwards against a stainless steel deflector to redirect the water onto the media evenly across its full width. A PVC union shall be provided in riser pipe below header pipe to facilitate removal of header pipe.

2.6 ACCESSORIES

A. Electrical Controls: Unit shall be provided with a fused disconnect and a magnetic across the line starter and separate contactor for control of water distribution. The electrical controls housing shall be NEMA 3.

B. Provide face louver panel constructed of aluminum all 5052 and shall contain bird screen attached to downstream side of panel frame. Louver panel shall be manufactured with welded panels to frame.

C. Pump Protection: Provide a low water level protection system to stop the pump in the event the sump level is too low for pump operation.

D. Provide automatic flush system on the sump through a solenoid valve that will be opened by a 24 hour timer. At the end of timing cycle solenoid valve will close and sump will refill.

E. Freeze protection for the unit shall be provided to prevent damage to unit due to freezing. Protection system shall consist of a minimum of thermal controller, drain solenoid, make up water solenoid and associated electrical control system. At temperature drop to 40F(ADJ) level, the system will shut off the supply water, open sump drain solenoid and shut off pump. On temperature rise to pre set(50-60F) level, the unit will be re-activated by the reverse action above. The pump will be delayed on start until the make up water has filled the sump to a safe level.

2.7 ROOF CURBS

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
   1. Curb and Adhesive: Comply with NFPA 90A or NFPA 90B.
      a. Materials: ASTM C1071, Type I or Type II.

B. Curb Height: 14 inches.

2.8 CONTROLS

A. Control Devices:
   1. Remote Thermostat: Adjustable room thermostat with temperature readout.
   2. UL508A Custom Control Panel for Evaporative Cooler units.
      a. Hoffman Concept Type 4 enclosure.
      b. Solid, painted back panel.
      c. Control Panel shall have single point connection for electrical power.
      d. Main fused disconnect w/class J, time delay, dual element fuses.
      e. Thru the door, interlocked, padlock-able, defeat-able main fused disconnect handle.
      f. IEC fan starter.
         1) Contactor rated for motor horsepower.
         2) Bimetallic, adjustable overload relay.
         3) Contactor top mount aux contact block.
         4) Contractor for Exhaust fans EF-1, 3HP, 480V, 24VAC coil.
      g. Pump IEC contactor w/24VAC coil.
      h. Control transformer, 1kVA, 480-120VAC, fused primary and secondary - for pump power and 120VAC control circuit.
      i. Control transformer, 150VA, 480-24VAC, fused primary and secondary - for 24VAC control circuit.
      j. Freeze Control w/Ranco programmable temperature controller, temp probe extends out bottom of enclosure via water-tight strain relief.
      k. Auto Flush Control w/Intermatic programmable 24 hr. timer mounted in handy box inside ICP.

l. Fan run time minimization ("AUTO")
   1) Damper actuator must open damper (close end switch) before start time delay begins.
   2) Time delay relay to prevent fan cycling via customer supplied blower bldg. temp control system fan start temp setting.

m. Door mounted IDEC HW series three position selector switches.
   1) "FAN - HAND/OFF/AUTO"
      a) "HAND" - Damper opens, fan runs.
      b) "OFF" - Fan off, damper closes.
      c) "Auto" - Fan runs via customer contact closure in blower bldg. temp control system - opens/closes damper, fan start/stop with time delays.
         1. Exhaust fan EF-unit_interlocked to run whenever DEC-_fan runs for Water Reuse Building.
   2) "PUMP - HAND/OFF/AUTO"
      a) "HAND" - Pump runs.
      b) "OFF" - Pump off.
      c) "Auto" - Pump runs via customer contact closure in Water Reuse bldg. temp control system.

n. Door mounted IDEC HW series, LED, green pilot lights.
   1) "FAN RUN"
   2) "PUMP RUN"

o. IDEC RH series, blade type control relays as needed, SPDT to 4PDT.

p. Customer terminal strip:
   1) Pump motor.
   2) Safety interlock (ships jumped).
   3) Low level float switch (ships jumped).
   4) Fan - customer "AUTO" contact.
   5) Pump - customer "AUTO" contact.
   6) Water inlet actuated valve.
   7) Water line drain back actuated valve.
   8) Sump drain actuated valve.
   9) DEC-_ fan starter N.O. dry contact.
   10) Damper 120VAC power.
   11) Damper end switch.
   12) Ground terminals.

q. All UL508A sizing, safety and warning labels.

r. Electrical schematic in folder.

s. Hot test in Varitec Panel Shop Test Lab.

t. Provide control panel layout drawing with Evaporative cooler unit submittal.

u. Building temperature system- Reuse Water Building:
   1) Outside air temp.
   2) Building air temp.
   3) Dry contacts for fan and pump start/stop.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine rough-in for piping, ducts and electrical systems to verify actual locations of piping and electrical connections before equipment installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. Verify cleanliness of airflow path to include inner casing surfaces, filters, fan wheels and other components.

3.2 INSTALLATION

A. Install outdoor evaporative cooler units with the following vibration control devices.
   1. Units with Internally Isolated Fans: Secure units to anchor bolts installed in concrete bases.
   2. Suspended Units: Suspend units from structural-steel support frame using threaded steel rods and spring hangers.

B. Arrange installation of units to provide access space around evaporative cooling units for service and maintenance.

C. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment.

D. Install controls and equipment shipped by manufacturer for field installation.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.

D. Electrical: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

E. Duct connections: Connect supply duct to unit with flexible duct connectors.
F. Ground equipment according to Division 26 Section "Grounding and Bonding."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
   1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Adjust initial temperature set points.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Final Checks before Startup: Perform the following:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connection to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Perform cleaning and adjusting specified in this Section.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
   5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
   6. Install clean filters.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing.

3.6 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain modular indoor air handling units.

END OF SECTION

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SECTION 23 81 26
SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes split-system air-conditioning units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Diagram power, signal, and control wiring.

B. Operation and Maintenance Data: For split-system air-conditioning units to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carrier Air Conditioning; Div. of Carrier Corporation.
   2. Mitsubishi Electronics America, Inc.; HVAC Division.
   3. Samsung.
   4. LG.

2.2 WALL OR CEILING MOUNTED, EVAPORATOR-FAN COMPONENTS

A. Cabinet: Enameled steel with removable panels on front and ends and discharge drain pans with drain connection.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with electronic linear expansion valve metering device. The expansion valve shall be controlled by a microprocessor controlled step motor.

C. Fan: Direct drive fan. The fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of four speeds.

D. Fan Motors:
   1. Special Motor Features: Multi-tapped, multispeed with internal thermal protection and permanent lubrication.

E. Filters: Removable and washable.

F. A dry air holding charge shall be provided in the indoor fan section.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

A. Casing: Steel, finished with baked enamel with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Compressor: The compressor shall be a DC twin rotor rotary compressor with variable speed inverter drive. The compressor shall be driven by inverter circuit to control compressor speed. Provide a minimal amount of current shall be automatically, intermittently applied to compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is needed.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler. The outdoor condensing unit shall have an accumulator and high pressure safety switch.

D. Fan: Aluminum-propeller type, directly connected to motor.

E. Motor: Permanently lubricated, with integral thermal-overload protection.

F. Refrigerant: R-410A. The outdoor unit shall be pre-charged with R-410A refrigerant in refrigerant tubing or compressor/coil.

G. The outdoor condensing unit shall be compatible with different types of indoor fan coil units, ceiling suspended, ducted, wall mounted or four way recessed ceiling cassette.

H. The outdoor condensing unit shall be equipped with an electronic control board that interfaces with indoor fan coil unit to perform all necessary operation functions.

2.4 ACCESSORIES

A. The control system shall contain a microprocessor for indoor units and one microprocessor for outdoor units. The indoor microprocessor shall be the capabilities to monitoring return air temperature, indoor coil temperature, receiving and processing commands from wired controller and controlling the outdoor unit. Provide a 24VDC for control signal between the indoor and outdoor unit.

B. Thermostat: Wired remote controller functioning to remotely control compressor and evaporator fan, with the following features:
   1. Compressor time delay.
   2. 24-hour time control of system stop and start.
   3. LCD display indicating built in temperature sensor, set-point temperature, time setting, operating mode, timer and fan speed.
   4. Fan-speed selection, including auto setting.
   5. 12/24 volts control voltage from wired controller to indoor unit.

C. Refrigerant Line Kits: Annealed, ARC type copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends; individually insulated in flexible, closed cell elastomeric material with thermal conductivity equal to 0.27 BTU-inch/hour per sqft per deg F. and flame spread index of less than 25 tested by ASTM E84.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounting compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

D. Install seismic restraints.

E. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch.

F. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other related Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to unit to allow service and maintenance.

C. Unless otherwise indicated, connect piping with unions and shutoff valves to allow units to be disconnected without draining piping. Refer to piping system Sections for specific valve and specialty arrangements.

D. Ground equipment.

3.3 FIELD QUALITY CONTROL

A. Contractor to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

DIVISION 26
ELECTRICAL

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SECTION 26 00 00
ELECTRICAL WORK, GENERAL

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide the electrical WORK, complete and operable, as indicated in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all Sections in Division 26, except as otherwise indicated.

C. The WORK of this Section is required for operation of electrically-driven equipment provided under Specifications in other Divisions.

D. The CONTRACTOR'S attention is directed to the requirement for proper coordination of the WORK of this Section with the WORK of equipment Specifications, the WORK of instrumentation Sections, and the WORK of Section 26 05 10 – Electric Motors.

E. Concrete, excavation, backfill, and steel reinforcement required for encasement, installation, or construction of the WORK of the various Sections of Division 26 is included as a part of the WORK under the respective Sections, including duct banks, manholes, handholes, equipment housekeeping pads, and light pole bases.

F. Equipment supports and foundations shall be in conformance with the requirements of Section 11 00 00 – Equipment General Provisions.

1.2 REFERENCE STANDARDS

NEC (NFPA 70)	National Electrical Code: 2020 Edition
NETA	International Electrical Testing Association
NEMA 250	Enclosure for Electrical Equipment (1000 Volts Maximum)

A. Electrical equipment shall be listed by and shall bear the label of Underwriters' Laboratories, Inc. (UL) or an independent testing laboratory acceptable to the local code enforcement agency having jurisdiction.

B. Installation of electrical equipment and materials shall comply with OSHA Safety and Health Standards (29 CFR 1910 and 29 CFR 1926, as applicable), state building standards, and applicable local codes and regulations.

C. Where the requirements of the specifications conflict with UL, NEMA, NFPA, or other applicable standards, the more stringent requirements shall govern.

1.3 SIGNAGE AND MARKINGS

A. Identification

1. Provide danger, caution, and warning signs and equipment identification markings in accordance with applicable federal, state, OSHA, and NEC requirements.

B. Local Disconnect Switches

1. Legibly mark each local disconnect switch for motors and equipment in order to indicate its purpose, unless the purpose is indicated by the location and arrangement.

C. Warning Signs

1. 600 Volts Nominal, or Less

a. Mark entrances to rooms and other guarded locations that contain live parts with conspicuous signs prohibiting unqualified persons from entering.

D. Isolating Switches

1. Provide isolating switches not interlocked with an approved circuit-interrupting device with a sign warning against opening them under load.

1.4 PUBLIC UTILITIES REQUIREMENTS

A. Contact the serving utility and verify compliance with requirements before construction.

1. Serving utility is Rocky Mountain Power; point of contact is Nicolas Boon (Nicolas.boon@pacificorp.com)

B. Coordinate schedules and payments for WORK by utilities.

C. Where conduits and conductors in the WORK are indicated to be larger, heavier schedule, or have greater protective coating than utility requirements, provide the larger size, heavier schedule, or greater protection.

D. Provide electrical service as indicated and as required by the serving utility.

E. Verify and provide service conduits, fittings, transformer pad, grounding devices, and service wires not provided by the serving utility.

F. Verify with the utility the exact location of each service point and type of service, and pay charges levied by the serving utilities as part of the WORK.

1.5 PERMITS AND INSPECTION

A. Obtain permits and pay inspection fees according to the General Conditions.

B. Pay connection and turn-on service charges required by the utility company.

1.6 CONTRACTOR SUBMITTALS

A. General

1. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

2. Custom-prepare Shop Drawings.

3. Drawings or data indicating "optional" or "as required" equipment will not be accepted.

4. Cross out options not proposed or delete from the Shop Drawings.

B. Shop Drawings: Include the following:

1. complete material lists stating manufacturer and brand name of each item or class of material.

2. Shop Drawings for grounding WORK not specifically indicated

3. front, side, rear elevations, and top views with dimensional data

4. location of conduit entrances and access plates

5. component data

6. connection diagrams, terminal numbers, internal wiring diagrams, conductor size, and cable numbers

7. method of anchoring, seismic requirements, weight

8. types of materials and finish

9. nameplates

10. temperature limitations, as applicable

11. voltage requirement, phase, and current, as applicable

12. front and rear access requirements

13. test reports

14. grounding requirements

C. Catalog Cuts

1. Submit catalog cuts or photocopies of applicable pages of bulletins or brochures for mass produced, non-custom manufactured material.

2. Stamp the catalog data sheets in order to indicate the Project name, applicable Specifications Section and Paragraph, model number, and options.

D. Materials and Equipment Schedules

1. Within 30 Days of the commencement date in the Notice to Proceed, deliver to the ENGINEER a complete list of materials, equipment, apparatus, and fixtures that are proposed for use.

2. Include in the list the type, size, name of manufacturers, catalog number, and such other information as required to identify the item.

E. Technical Manuals

1. Submit complete information in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

2. As-Built Drawings

a. Prepare as-built drawings, showing invert and top elevations and routing of duct banks and concealed below-grade electrical installations.

b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

1.7 AREA DESIGNATIONS

A. General

1. Designations for raceway system enclosures shall comply with the requirements of Section 26 05 33 – Electrical Raceway Systems.

2. Designations for electrical WORK specifically indicated in other Sections shall comply with the requirements of those Sections unless indicated otherwise.

3. Designations for other electrical WORK not included in the above Paragraphs shall be as follows:

AREA	NEMA ENCLOSURE CLASSIFICATION					
	1	3R	4X	9	12	Notes
Electrical Room					x	
Pump Room			x			Damp area
Dry well			X			Damp area
Exterior		x				

4. Designations for electrical WORK not included in the above Paragraphs shall be NEMA 4X.

5. Installations in hazardous locations shall conform strictly to the requirements of the indicated Class, Group, and Division.

B. Material Requirements

1. Construct NEMA 4X enclosures of Type 304 or 316 stainless steel, except in chlorine and HFS areas where non-metallic enclosures shall be provided.

2. Do not coat NEMA 4X enclosures.

3. Construct NEMA 1, 3R, and 12 enclosures of steel, and prime and coat with ANSI 61 light grey paint.

1.8 TESTS

A. The CONTRACTOR shall be responsible for factory and field tests indicated in Division 26, as required by the ENGINEER, and as required by other authorities having jurisdiction.

B. Furnish necessary testing equipment.

C. Pay the costs of the tests, including replacement parts and labor, due to damage resulting from damaged equipment or from testing and correction of a faulty installation.

D. Reporting

1. Where test reporting is indicated, submit proof-of-design test reports for mass-produced equipment with the Shop Drawings.

2. Submit factory performance test reports for custom-manufactured equipment for approval prior to shipment.

3. Submit field test reports for review prior to Substantial Completion.

E. Remove and replace equipment or material that fails a test, or, if the ENGINEER approves, repair and retested for compliance.

F. Corrections to equipment or materials with a factory warranty shall be as recommended by the manufacturer and shall be performed in a manner that does not void the warranty.

1.9 CONSTRUCTION SEQUENCING

A. General

1. Because the continuance of plant operation during the expansion process is critical, the CONTRACTOR shall carefully examine the WORK to be provided in, on, or adjacent to existing equipment.

2. In no case shall the CONTRACTOR begin any WORK in, on, or adjacent to existing equipment without written authorization from the ENGINEER.

B. Modifications

1. Perform modifications or alterations to existing electrical facilities as required to successfully install and integrate the proposed electrical equipment as indicated.

2. Perform modifications to existing equipment, panels, and cabinets in a professional manner.

3. Repair coatings to match existing.

4. The costs for modifications to existing electrical facilities that are required for a complete and operating system shall be included as part of the WORK.

C. Existing Utilities

1. Exercise extreme caution when digging trenches to not damage existing underground utilities.

2. The cost of repairs of damages caused during construction shall be included as a part of the WORK.

D. Field Verifications

1. Visit the Site before submitting a Bid to become better acquainted with the WORK of this Contract.

2. The lack of knowledge will not be accepted as justification for extra compensation to perform the WORK.

3. The cost for the above verifications shall be included as part of the WORK.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Provide equipment and materials that are new and are the products of experienced and reputable manufacturers in the industry.

B. Provide equipment and materials listed by UL and bearing the UL label, where UL requirements apply.

C. Provide similar items in the WORK as products of the same manufacturer.

D. Provide equipment and materials of industrial grade standard of construction.

E. Where a NEMA enclosure type is indicated in a non-hazardous location, use that type of enclosure despite the fact that certain modifications such as cutouts for control devices may negate the NEMA rating.

F. On devices indicated to display dates, display the year as 4 digits.

G. Temperature Ratings of Equipment Terminations

1. Provide terminations and lugs rated for use with 75-degree C conductors.

2. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75-degree C ratings.

2.2 MOUNTING HARDWARE

A. Miscellaneous Hardware

1. Provide nuts, bolts, and washers constructed of stainless steel.

2. Provide threaded rods for trapeze supports constructed from continuous threaded galvanized steel, 3/8-inch diameter minimum.

3. Struts

a. Construct struts for mounting of conduits and equipment of aluminum.

b. Where contact with concrete or dissimilar metals may cause galvanic corrosion, use suitable non-metallic insulators in order to prevent such corrosion.

c. Do not use aluminum strut for free-standing support frames.

d. Strut Manufacturer, or Equal: **Unistrut**; **B-Line**

4. End Caps

a. Provide plastic protective end caps for all exposed strut ends below 8' AFF.

b. End Caps Manufacturer, or Equal: **Unistrut, Model P2860**

5. Anchors

a. Provide stainless steel expansion anchors for attaching equipment to concrete walls, floors, and ceilings.

b. Wood plugs will not be accepted.

c. Anchor Manufacturer, or Equal: **"Power-Bolt"** or **"Power-Stud"** as manufactured by **Power Fasteners, Inc.**; similar by **Star**.

2.3 ELECTRICAL IDENTIFICATION

A. Nameplates

1. Fabricate nameplates from white-letter, black-face laminated plastic engraving stock, such as **Formica Type ES-1** or equal.

2. Securely fasten each nameplate, using fasteners constructed of brass, cadmium-plated steel, or stainless steel, and screwed into inserts or tapped holes as required.

3. Provide engraved characters of the block style, with no characters smaller than 1/8 inch top to bottom.

B. Conductor and Equipment Identification

1. Provide imprinted plastic-coated cloth marking devices, such as manufactured by Brady, Thomas & Betts, or equal.

2. Alternatively, provide heat-shrunk plastic tubing, imprinted split-sleeve markers cemented in place.

2.4 PROTECTIVE MATTING

A. Provide full-width, high-voltage switchboard matting in front of indoor switchgear, service equipment, panelboards and motor control centers.

B. For 600-volt equipment, provide matting that is 1/4 inch thick and 36 inches wide.

C. Matting Manufacturer, or Equal

1. W.H.Salisbury and Company; Mats, Inc.; Rhino

PART 3 -- EXECUTION

3.1 GENERAL

A. Incidentals

1. Provide materials and incidentals required for a complete and operable system, even if not required explicitly by the Contract Documents.

2. Typical incidentals are terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and control wiring required by vendor-furnished equipment to connect with other equipment indicated in the Contract Documents.

B. Field Control of Location and Arrangement

1. The Drawings diagrammatically indicate the desired location and arrangement of outlets, conduit runs, equipment, and other items.

2. Exact locations shall be determined by the CONTRACTOR in the field, based on the physical size and arrangement of equipment, finished elevations, and other obstructions.

3. Follow the locations on the Drawings, however, as closely as possible.

4. Conduits

a. Where conduit development drawings or "home runs" are indicated, route the conduits in accordance with those requirements.

b. Provide exposed or encased routings as indicated, except conceal conduit in finished areas unless indicated otherwise.

c. Size conduits encased in a slab for conduit OD not to exceed 1/3 of the slab thickness, and lay out and space as to not impede concrete flow.

5. Placement

a. Install conduit and equipment in such a manner as to avoid obstructions, to preserve headroom, and to keep openings and passageways clear.

b. Locate luminaires, switches, convenience outlets, and similar items within finished rooms as indicated.

c. Where exact locations are not indicated, such locations will be determined by the ENGINEER.

d. If equipment is installed without instruction and must be moved, the cost of moving shall be included as part of the WORK.

e. Slightly adjust luminaire locations in order to avoid obstructions and to minimize shadows.

6. Circuits

a. Wherever conduits and wiring for lighting and receptacles are not indicated, it shall be the CONTRACTOR'S responsibility to provide lighting and receptacle-related conduits and wiring as required, based on the actual installed fixture layout and the circuit designations as indicated.

b. Provide No. 12 AWG minimum wiring, and 3/4-inch minimum conduits (exposed) and one-inch minimum conduits (encased).

c. Where circuits are combined in the same raceway, derate conductor ampacities in accordance with NEC requirements.

7. Workmanship

a. Install materials and equipment in strict accordance with the printed recommendations of the manufacturer, and using workers skilled in the WORK.

b. Coordinate installation in the field with other trades in order to avoid interferences.

8. Protection of Equipment and Materials

a. Fully protect materials and equipment against damage from any cause.

b. Cover materials and equipment, both in storage and during construction, in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint.

c. Keep moving parts clean and dry.

d. Replace or refinish damaged materials or equipment, including faceplates of panels and switchboard sections, as part of the WORK.

C. Provide incoming utility power equipment in conformance with the utility's requirements.

D. Provide starters in accordance with the requirements of Section 26 05 15 – Industrial Control Panels for starters not in MCC'S.

3.2 CORE DRILLING

A. Perform core drilling as required for the installation of raceways through concrete walls and floors.

B. Base the locations of floor penetrations, as may be required, on field conditions.

C. Verify exact core drilling locations based on equipment actually furnished as well as exact field placement.

D. To the extent possible, identify the existence and locations of encased raceways and other piping in existing walls and floors with the OWNER prior to any core drilling activities.

E. Repair damage to encased conduits, wiring, and piping as part of the WORK.

3.3 CONCRETE HOUSEKEEPING PADS

A. Provide concrete housekeeping pads for indoor floor-standing electrical equipment.

B. Extend housekeeping pads for equipment, including future units, 3-1/2 inches above the surrounding finished floor or grade, and 2 inches larger in both dimensions than the equipment, unless otherwise indicated.

C. Provide concrete housekeeping curbs for conduit stub-ups in indoor locations that are not concealed by equipment enclosures.

D. Extend housekeeping curbs to 3 inches above the finished floor or grade.

3.4 EQUIPMENT ANCHORING

A. Floor-supported, wall, or ceiling-hung equipment and raceways shall be anchored in place by methods that will meet seismic requirements in the area where the Project is located. Refer to Section 01 33 17 – Structural Design, Support and Anchorage for support and anchorage requirements.

B. Provide wall-mounted panels that weigh more than 500 pounds or that are within 18 inches of the floor with fabricated steel support pedestals.

C. If the supported equipment is a panel or cabinet enclosed within removable side plates, match supported equipment in physical appearance and dimensions.

D. Provide transformers hung from 4-inch stud walls and weighing more than 300 pounds with auxiliary floor supports.

E. Provide leveling channels anchored to the concrete pad for MCC's, switchgear and other electrical equipment mounted on housekeeping pads.

F. Manufacturer's Recommendations

1. Anchoring methods and leveling criteria in the printed recommendations of the equipment manufacturers are a part of the WORK of this Contract.

2. Submit such recommendations as Shop Drawings as indicated.

3.5 EQUIPMENT IDENTIFICATION

A. Provide nameplates for panelboards, control and instrumentation panels, starters, switches, and pushbutton stations.

B. In addition to nameplates, equip control devices with standard collar-type legend plates.

C. Identify control devices within enclosures as indicated and similar to the subparagraph above.

D. Provide suitable inscribed finish plates for toggle switches that control loads out of sight of switches and for multi-switch locations of more than 2 switches.

E. Use equipment names and tag numbers, where indicated, on nameplates.

F. Provide typewritten circuit directories for panelboards, that accurately reflect the outlets connected to each circuit.

G. Terminal Blocks

1. Label termination points on terminal blocks by identifiers on the blocks.

2. Provide identifiers that have been preprinted by the terminal manufacturer or custom-printed.

3. Hand-lettered markers will not be accepted.

H. Provide arc-flash labels for all distribution equipment, stand-alone disconnects, starters, and VFDs. Fill in all values as required by NFPA 70E, and as calculated as part of the Protective Device Study. Verify that all settings as prescribed by the approved Protective Device Study have been implemented in the field.

3.6 CLEANING

A. Before final acceptance, thoroughly clean the electrical WORK of cement, plaster, and other materials.

B. Remove temporary tags, markings, stickers, and the like.

C. Remove oil and grease spots with a non-flammable cleaning solvent by carefully wiping and scraping cracks and corners.

D. Apply touch-up paint to scratches on panels and cabinets.

E. Vacuum clean electrical cabinets and enclosures. Do not use compressed air to clean cabinets.

F. Clean luminaires inside and out. Replace failed lamps.

G. Properly dispose cleaning debris and refuse off-site.

END OF SECTION

SECTION 26 01 26
ELECTRICAL TESTS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. This Section specifies the WORK necessary to test, commission, and demonstrate that the electrical work satisfies the criteria of these Specifications and functions as required by the Contract Documents.

B. The WORK of this Section includes furnishing the labor, equipment, and power required to support the testing indicated in other Divisions of these Specifications. Electrical testing indicated herein and functional testing of power and controls not tested under Division 40 - Instrumentation, shall be completed before commencement of the 7 Day test of Section 017500 - Equipment Testing and Plant Startup. This scope may require the CONTRACTOR to activate circuits, shutdown circuits, run equipment, make electrical measurements, replace blown fuses, and install temporary jumpers, etc.

C. The requirements of Section 26 00 00 - Electrical Work, General, apply to the WORK of this Section.

D. Carry out tests indicated herein for individual items of materials and equipment in other Sections. Testing shall be done in accordance with the manufacturer's instructions, these Specifications, and applicable NETA Acceptance Testing Specifications, NEMA, ANSI, NFPA, and ASTM Standards.

1.2 REFERENCES

A. General

1. The publications listed below form a part of this specification to the extent referenced.

2. Where a date is given for reference standards, the edition of that date shall be used. Where no date is given for reference standards, the latest edition available on the date of the Notice Inviting Bids shall be used.

B. American National Standards Institute (ANSI)

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE)

D. IEEE 400-2001, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems

E. IEEE 576-2000, Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications

F. InterNational Electrical Testing Association (NETA)

G. NFPA 70, National Electrical Code (NEC)

1.3 SUBMITTALS

A. Submit in accordance with Section 01 33 00, Submittals.

B. Submit complete system test procedures for review. Test procedures shall include but not be limited to:

1. Detailed procedures in sufficient detail to verify conformance with these Specifications.

2. Incorporation of the Test Record Sheets included at the end of this Section.

3. Detailed comprehensive testing schedule including:

a. Each major piece of electrical distribution equipment.

b. Each major electrical subsystem.

c. Duration of each test.

d. Milestone test completion date.

e. Ambient Conditions at time of test

f. Date of test results submittals following completion of the tests.

g. Names and qualifications of the individual(s) responsible for performing the testing.

C. Following completion of the test submit the completed test results to the Engineer for review. The results shall include a dedicated section with the "as-left" settings of all devices, relays, circuit breakers, etc.

D. Test result shall be submitted in one submittal

E. Test reports shall be based on NETA's latest Acceptance Testing Specifications having a sign-off, pass/fail data filed for each line item covered by NETA's Acceptance Testing Specifications latest edition.

1.4 COMMISSIONING

A. Commissioning during the 7 Day test in Section 01 75 00 shall not be attempted until all subsystems have been found to operate satisfactorily. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable. Simulation of process parameters shall be considered only upon receipt of a written request by the CONTRACTOR.

B. Motor Current Tabulation

1. The motor current tabulation required by Section 26 05 73 – Protective Device Studies shall reflect the values occurring during commissioning.

2. Switchboard ammeters and kilowattmeters shall be recorded every half-hour during the commissioning.

3. Power monitored amperes, voltage, and kilowatts for each phase shall be recorded every 5 minutes during commissioning.

PART 2 -- TESTING & REPORTS

2.1 PRE-ENERGIZATION AND OPERATING TESTS

A. The complete electrical system shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the recommendations of the protective device study and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the authority having jurisdiction.

1. Instrument Transformers. All instrument transformers shall be tested to verify correct polarity and burden.

2. Protective Relays. Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.

3. Switching Circuits. Each switching circuit shall be observed to operate the associated equipment being switched.

4. Control and Signal Circuits. Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.

5. Metering Circuits. All metering circuits shall be verified to operate correctly from voltage and current sources, similarly to protective relay circuits.

6. Acceptance Tests. Complete acceptance tests shall be performed, after the station installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.

7. Relays and Metering Utilizing Phase Differences. All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.

B. Test Report. A test report covering the results of the tests required in the Pre-Energization and Operating Tests shall be delivered to the authority having jurisdiction prior to energization. Acceptance Testing shall be in accordance with NETA ATS-2017, *For Electrical Power Equipment and Systems*, published by the InterNational Electrical Testing Association.

2.2 TEST REQUIREMENTS

A. The following test requirements supplement test and acceptance criteria that may be stated elsewhere.

1. Lighting: Switching, include remote control, if present in system. Circuitry is in accordance with panel schedules. All interior and exterior lighting shall be checked for proper operation.

2. Power Instrumentation: Demonstrate that voltmeter and ammeter switches are functional. Demonstrate that kilowatt meters are within catalog accuracy as installed.

a. Visual and Mechanical Inspection

1) Compare equipment nameplate data with drawings and specifications.

2) Inspect physical and mechanical condition.

3) Verify tightness of electrical connections.

4) Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case-shorting contacts, as applicable.

5) Verify freedom of movement, end play, and alignment of rotating disk(s).

b. Electrical Tests

1) Verify accuracy of meters at all cardinal points.

2) Calibrate watthour meters according to manufacturer's published data.

3) Verify all instrument multipliers.

4) Verify that current transformer and voltage transformer secondary circuits are intact.

3. Demonstrate mechanical and/or electrical interlocking by attempting to subvert the intended sequence.

4. Activate ground fault tripping by operating test features provided with ground current protective systems and by injecting a known and reasonable current in the ground current sensor circuit. In general, ground fault tripping should occur at a ground current equivalent to 20 percent of phase current. Current injection is not required of circuit 400 amperes or less.

5. Low Voltage Cables-600 volts Maximum

a. Visual and Mechanical Inspection

1) Compare cable data with drawings and specifications.

2) Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagram.

3) Inspect bolted electrical connections for high resistance using one of the following methods:

a) Use of low-resistance ohmmeter

b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS- 2017, Table 100.12.

c) Perform thermographic survey in accordance with below Section Thermographic Survey.

4) Inspect compression-applied connectors for correct cable match and indentation.

5) Inspect for correct identification and arrangements.

6) Inspect cable jacket insulation and condition.

b. Electrical Tests

1) Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.

a) Motor feeders tested with motors disconnected and controller open.

b) Motor control circuits tested and verified for proper operation with control stations and overcurrent devices connected.

c) Panelboard feeders tested with feeder breaker open and panel-board connected. If a lighting transformer is associated with the panelboard, it shall be connected and the test made for both primary and secondary sides.

d) Conductors of main lighting feeders, including lighting panel with branch circuits open.

e) Prior to performing insulation resistance tests on cables, verify that they are not connected to a solid state device.

f) Equipment which may be damaged during this test shall be disconnected.

g) The Engineer shall be consulted if minimum insulation values cannot be obtained.

2) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

3) Perform continuity test to insure correct cable connection.

c. Test Values – Visual and Mechanical

1) Compare bolted connection resistance to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Bolt-torque levels should be in accordance with NETA ATS-2017, Table 100.12 unless otherwise specified by the manufacturer.

3) Results of the thermographic survey shall be in accordance with the below Section Thermographic Survey.

d. Test Values – Electrical

1) Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS-2017 Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.

3) Cable shall exhibit continuity.

4) Deviations in resistance between parallel conductors shall be investigated.

6. Test ground interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle manufacturer.

7. A functional test and check of electrical components is required prior to performing subsystem testing and commissioning. Compartments and equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing. Functional testing shall comprise:

a. Visual and physical check of cables, circuit breakers, transformers, and connections associated with each item of new and modified equipment.

b. Verification that electrical equipment has been labeled with Arc Flash protection boundary and PPE levels, as required by Section 26 05 73 – Protective Device Studies.

c. Setting of protective relays in conformance with results of the Short Circuit Study required by Section 26 05 73 - Protective Device Studies and testing of relays to assure that relays will trip at the current value and time required by the Study.

d. Circuit Breakers

1) Circuit breakers that have adjustable time or pick-up settings for ground current, instantaneous overcurrent, short-time overcurrent, or long-time overcurrent, shall be field-adjusted by a representative of the circuit breaker manufacturer.

2) Time and pickup setting shall correspond to the recommendations of the Short Circuit Study.

3) Setting shall be tabulated and proven for each circuit breaker in its installed position.

4) Test results shall be certified by the person performing the tests and shall be submitted to the ENGINEER.

8. Complete ground testing of grounding electrodes per requirements below prior to operating the equipment.

B. Subsystem testing shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the ENGINEER and after process control devices have been adjusted as accurately as possible. Alarm conditions shall be simulated for each alarm point, and alarm indicators shall be checked for proper operation. It is intended that the CONTRACTOR will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.

C. Metering and indication lights for motors and other devices shall be tested for proper operation.

D. All control circuits such as motor, interlock and remote shall be tested for proper operation.

E. After initial settings have been completed, each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract Documents. Once the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc.

F. Motor operated valves shall be tested after having been phased and tested for correct motor rotation and after travel and torque limit switches have been adjusted by a representative of the valve manufacturer. Tests shall verify status indication, proper valve travel, and correct command control from local and remote devices.

G. All lighting panels, circuits and fixtures; and power panels, circuits and receptacles shall be tested for proper operation.

H. Provide ground resistance tests on the main grounding electrode or system in the presence of the ENGINEER and submit results

1. Visual and Mechanical Inspection

a. Verify ground system is in compliance with drawings and specifications.

2. Electrical Tests

a. Perform fall-of-potential test or alternative in accordance with IEEE Standard 81 on the main grounding electrode or system.

b. The earth resistance of each ground electrode shall be measured and recorded before electrodes are connected to the grounding loop.

c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

3. Test Values

a. The resistance between the main grounding electrode and ground shall be no greater than five ohms for commercial or industrial systems and one ohm or less for generating or transmission station grounds unless otherwise specified by the owner.

b. Investigate point-to-point resistance values which exceed 0.5 ohm.

I. Subsystems shall be defined as individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, etc.

J. THERMOGRAPHIC SURVEY

1. Visual and Mechanical Inspection

a. Inspect physical, electrical, and mechanical condition.

b. Remove all necessary covers prior to thermographic inspection. Utilize appropriate caution, safety devices, and personal protective equipment.

2. Equipment to be inspected shall include all 120 volt and higher current-carrying devices including all switchgear, switchboards, distribution panels, cable and bus connections, motor control centers and starters, disconnect switches, and other critical equipment. Testing of lighting luminaires, field instrumentation, SCADA & PLC's are not required.

3. Provide report including the following:

a. Description of equipment to be tested.

b. Discrepancies.

c. Temperature difference between the area of concern and the reference area.

d. Probable cause of temperature difference.

e. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.

f. Identify load conditions at time of inspection.

g. Provide photographs and/or thermograms of the deficient area.

h. Recommended action.

4. Test Parameters

a. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1°C at 30°C.

b. Equipment shall detect emitted radiation and convert detected radiation to visual signal.

c. Thermographic surveys should be performed during periods of maximum possible loading but not less than 40 percent of rated load of the electrical equipment being inspected. Refer to ANSI/NFPA 70B-2010, Section 11-17 (Infrared Inspection).

5. Test Values

a. Suggested actions based on temperature rise can be found in Table 100.18.

6. RE-INSPECTION

a. All items that are reported deficient in the thermography reports section of the inspection report shall be re-inspected after repairs have been made.

b. Original specification will apply to re-inspections.

c. Submit re-inspection reports and indicate that repairs have fixed the anomaly or indicate any remaining anomalies.

d. Perform a follow-up thermographic survey within 12 months of final acceptance by the owner.

2.3 TEST REPORTS

A. The test report shall include the following:

1. Summary of project.

2. Description of equipment tested.

3. Description of test.

4. Test data.

5. Analysis and recommendations.

B. Test data records shall include the following minimum requirements:

1. Identification of the testing organization.

2. Equipment identification.

3. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.

4. Date of inspections, tests, maintenance, and/or calibrations.

5. Identification of the testing technician.

6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.

7. Indication of expected results when calibrations are to be performed.

8. Indication of "as-found" and "as-left" results.

9. Sufficient spaces to allow all results and comments to be indicated.

C. The testing firm shall furnish a copy or copies of the complete report to the owner as required in the acceptance contract.

TABLE 100.18

THERMOGRAPHIC SURVEY
SUGGESTED ACTIONS BASED ON TEMPERATURE RISE

Temperature difference (ΔT) based on comparisons between similar components under similar loading.	Temperature difference (ΔT) based upon comparisons between component and ambient air temperatures.	Recommended Action
1ºC - 3ºC	1ºC - 10ºC	Possible deficiency; warrants investigation
4ºC - 15ºC	11ºC - 20ºC	Indicates probable deficiency; repair as time permits
- - - - - -	21ºC - 40ºC	Monitor until corrective measures can be accomplished
>15ºC	>40ºC	Major discrepancy; repair immediately

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables) there are various temperature ratings. Heating is generally related to the square of the current; therefore, the load current will have a major impact on

ΔT. In the absence of consensus standards for ΔT, the values in this table will provide reasonable guidelines.

An alternative method of evaluation is the standards-based temperature rating system as discussed in Chapter 8.9.2, Conducting an IR Thermographic Inspection, *Electrical Power Systems Maintenance and Testing*, by Paul Gill, PE, 1998.

It is a necessary and valid requirement that the person performing the electrical inspection be thoroughly trained and experienced concerning the apparatus and systems being evaluated as well as knowledgeable of thermographic methodology

PART 3 -- TEST RECORD SHEETS

The test record sheets listed below shall be used to record testing of electrical equipment and of the electrical installation as required by these specifications. Sample copies of each sheet are attached.

Sheet No.	Title
1	Insulation Resistance (Power, Control Wire, and Cable) Test Record
2	Insulation Resistance (Instrument Wire and Cable) Test Record
3	Not Used
4	Ground Electrode Testing Test Record
5	Not Used
6	Bonding Resistance Readings (Nonelectrical Equipment/Structures) Test Record
7	Bonding Resistance Readings (Electrical Equipment) Test Record
8	Insulation Resistance (Transformer) Test Record
9	Insulation Resistance (Equipment) Test Record
10	Insulation Resistance (Rotating Equipment) Test Record
11	Equipment Absorption Ratio and Polarization Index Test Record
12	Record Feeder Breaker (480 V MCC) Test Record
13	Breaker/Contactor (480 V MCC) Test Record
14	460 V Motor Circuit (480 V MCC) Test Record
15	Not Used
16	Electric Motor Run-In Test Record
17	Thermographic Test Record

INSULATION RESISTANCE
(POWER, CONTROL WIRE, AND CABLE)
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC _____ ºF DATE: _____

NOTES: 1. Perform Insulation Resistance Test (megger) between each conductor and all other conductors and metallic sheath for cables with nonshielded conductors. Test between each conductor and shield for multiconductor cables with shielded conductors. Record lowest reading for each cable.

2. Use 1,000-V test set for cable rated 600 volts and 2,500-V test set for cable rated over 600 volts.

3. Readings will vary inversely with temperature and cable length. When the use of temperature correction factors is specified, attach a second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Panel No. Circuit No. Feeder No.	Wire Tagging	Cable Rated Voltage	Wire or Cable Quantity	Insulation Size	From	To	Resistance (megohms)*	Initials

*Minimum acceptable values:

Cable Rated Voltage	Test Duration	Resistance for Cable Only	Cable/Wire Size or Amperage (megohms)	Resistance When Cable Connected to Equipment

(ohms)

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE
(INSTRUMENT WIRE AND CABLE)
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC ºF DATE: _____

NOTES: 1. Record only the lowest value.

2. MP - Multi-pair cable. SP - Single pair cable.
3. Megger with instruments disconnected.
4. Use 250 volt (or lower voltage, when specified) range on DC test set.
5. Readings will vary with temperature and cable length.*

Cable Number or Instrument Number	Indicate MP or SP Type (2)	Conductor to Conduit (Single Pair Non-Shielded Cables) (megohms)	Conductor to Conductor (megohms) (1)	Shield to Conductor to Shield (megohms) (1)	Overall Shield to Shield (Multipair Cables Only) (megohms) (1)	Lead and Armor (Multipair Cables Only (megohms)	Shield to Conduit (Single Pair Cables Only) (megohms)	Initials

DISTRIBUTION:

CONTRACTOR/Date _____

GROUND ELECTRODE TESTING
TEST RECORD

TEST EQUIPMENT: _____ (Note 1) _____ (Note 2)

REFERENCE DRAWING: _____ _____

NOTES: 1. Record resistance-to-earth for each electrode with all other conductors disconnected. Resistance not to exceed 25 ohms for any single anode.

2. Check continuity from each electrode to any test bar or other electrode such that the complete ground loop is tested.

Rod Number	Resistance to Earth (ohms)	Ambient Temperature (ºC/ºF)	Weather	Taps (□)	Initials/Date

DISTRIBUTION:

CONTRACTOR/Date _____

BONDING RESISTANCE READINGS
(NONELECTRICAL EQUIPMENT/STRUCTURES)
TEST RECORD

TEST EQUIPMENT USED: _____ WEATHER: _____

NOTES: 1. Vessels, tanks, and structural steel bonded to the main grounding system, dedicated ground rod or foundation, as indicated on drawings listed below.

2. Measure resistance from ground wire tap (or anchor bolt) to tagged equipment frame or structural steel.

EQUIPMENT TAG NO. OR STRUCTURE	DRAWING	MEASURED RESISTANCE (ohms)	INITIALS/DATE

DISTRIBUTION:

CONTRACTOR/Date _____

BONDING RESISTANCE READINGS
(ELECTRICAL EQUIPMENT)
TEST RECORD

TEST EQUIPMENT USED: _____ WEATHER: _____

NOTES: 1. Electrical equipment bonded to the main grounding system or dedicated ground rod, as indicated on drawings listed below.

2. Measure resistance from ground wire tap to tagged equipment bus bars, tagged equipment enclosures, and any other points indicated on the drawings.

EQUIPMENT TAG NO. OR STRUCTURE	DRAWING	MEASURED RESISTANCE (ohms)	INITIALS/DATE

CONTRACTOR/Date _____

INSULATION RESISTANCE
(TRANSFORMER)
TEST RECORD

SUBSTATION NO.: _____ TEST EQUIPMENT: _____

NOTES: 1. Use 1,000-V test set for 600-volt equipment and below, 2,500-V test set for equipment rated 601 - 5,000 volts, and 5,000-V test set for equipment rated over 5,000 volts.

2. Test voltage to be applied for 1-minute duration, and reading taken.
3. Neutral must be disconnected from ground during test.
4. Record temperature of surrounding air temperature for dry-type transformers.
5. Readings will vary inversely with temperature. When the use of temperature correction factors is specified, attach second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Equipment Tag No.	RESISTANCE IN (megahoms) *						Pri to Sec	Voltage Rating (kV)	Pri-Sec or Air	Liquid Temp. (ºC/ºF)
	Primary			Secondary						
	∅A to G	∅B to G	∅C to G	∅A to G	∅B to G	∅C to G				

*Minimum acceptable values:

VOLTAGE CLASS	RESISTANCE (megohms)

TESTER'S INITIALS/DATE _____

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE (EQUIPMENT)
TEST RECORD

TEST EQUIPMENT: _____ SUBSTATION: _____

AMBIENT TEMPERATURE: _____ ºC ºF DATE: _____

REFERENCE DRAWING: _____ REF. SEC.: _____

NOTES: 1. Use 1,000-V test set for equipment rated 600 volts and below, 2,500/5,000-V test set for equipment rated over 600 volts.

2. For equipment with solid state control circuits, consult manufacturer's literature for maximum test voltages.

Switchgear MCC (other)	INSULATION RESISTANCE (megohms) *						Test Voltage (kV)	Rated Voltage (kV)	Initials/ Date
	∅A to G	∅B to G	∅C to G	∅A to ∅B	∅B to ∅C	∅C to ∅A			

*Minimum acceptable values:

EQUIPMENT VOLTAGE CLASS (megohms)	RESISTANCE

TESTER'S INITIALS/DATE _____

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE (ROTATING EQUIPMENT)
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC ºF DATE: _____

EQUIP. TEMP., IF KNOWN: _____ ºC ºF HOW KNOWN: _____

NOTES: 1. Use 1,000-V test set for equipment 600-volt and below, 2,500/5,000-V test set for equipment rated over 600 volts.

2. Test duration shall be 1 minute, note if otherwise: _____.

3. Isolate all motor leads from one another and from frame, test phase separately, wherever practical.

4. Document testing of low voltage and medium voltage equipment on separate sheets.

5. Readings will vary inversely with temperature. When the use of temperature correction factors is specified, attach second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Equipment Tag No.	INSULATION RESISTANCE (megohms) *						Rated Voltage	Equipment Initial/Date
	∅A to G	∅B to G	∅C to G	∅A to ∅B	∅B to ∅C	∅C to ∅A		

*Minimum acceptable values:

VOLTAGE CLASS	RESISTANCE (megohms)

DISTRIBUTION:

CONTRACTOR/Date _____

EQUIPMENT ABSORPTION RATIO
AND POLARIZATION INDEX
TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ ºC ºF DATE: _____

EQUIP. TEMP., IF KNOWN: _____ ºC ºF REL. HUMIDITY: _____

NOTES: 1. Perform test as indicated on Test Records for each individual equipment type. Reference the following sheets:

Transformers	8
Equipment	9
Motors and Generators	10

2. Absorption Ratio = $\frac{\text{1-Minute Resistance Value}}{\text{30-Second Resistance Value}}$
3. Polarization Index = $\frac{\text{10-Minute Resistance Value}}{\text{1-Minute Resistance Value}}$

OHMS TO GROUND 30-SECOND READING ∅A TO GROUND	OHMS TO GROUND 1-MINUTE READING ∅A TO GROUND	OHMS TO GROUND 10-MINUTE READING ∅A TO GROUND	DIELECTRIC ABSORPTION RATIO	POLARIZATION INDEX
OHMS TO GROUND 30-SECOND READING ∅B TO GROUND	OHMS TO GROUND 1-MINUTE READING ∅B TO GROUND	OHMS TO GROUND 10-MINUTE READING ∅B TO GROUND	DIELECTRIC ABSORPTION RATIO	POLARIZATION INDEX
OHMS TO GROUND 30-SECOND READING ∅C TO GROUND	OHMS TO GROUND 1-MINUTE READING ∅C TO GROUND	OHMS TO GROUND 10-MINUTE READING ∅C TO GROUND	DIELECTRIC ABSORPTION RATIO	POLARIZATION INDEX

TESTER'S INITIALS/DATE _____

DISTRIBUTION:

CONTRACTOR/Date _____

FEEDER BREAKER (480 V MCC)
TEST RECORD

EQUIPMENT DESIGNATION			
LOAD (kW/kVA)		VOLTAGE F.L.A.	
CIRCUIT BREAKER MFG.		RATING	SETTING
CONDUCTOR SIZE	POWER	GROUND	

1. Check nameplate data of breaker against approved vendor drawings. _____
2. Check breaker components for cleanliness. _____
3. Check mechanical function of breaker. _____
4. Check wiring for proper identification. _____
5. Check conduits/cables for tagging. _____
6. Check components for identification. _____
7. Check equipment for conformance of area classification. _____
8. Check installation for seals, breathers, and drains. _____
9. Verify power conductor continuity. _____
10. Check that power cable insulation resistance test (megger) is completed. _____

DISTRIBUTION:

CONTRACTOR/Date _____

BREAKER/CONTACTOR (480 V MCC)
TEST RECORD

EQUIPMENT DESIGNATION			
LOAD (kW/kVA)		VOLTAGE F.L.A.	
CIRCUIT BREAKER MFG.		RATING	SETTING
CONTACTOR MFG.		SIZE	
CONDUCTOR SIZE	POWER	CONTROL GROUND	

1. Check nameplate data of breaker, contactor fuses and relays against approved vendor drawings. _____

2. Check main and auxiliary contacts. _____

3. Check contactor/breaker components for cleanliness. _____

4. Check control fuses, CPT rating, and coil voltage. _____

5. Check mechanical function of contactor and breaker. _____

6. Check wiring for proper identification. _____

7. Check conduits/cables for tagging. _____

8. Check components for identification. _____

9. Check equipment for conformance to area classification. _____

10. Check installation for seals, breathers, and drains. _____

11. Verify continuity of all power and control leads. _____

12. Check that power and control cable Insulation Resistance Test (megger) is completed. _____

13. Complete functional operation check of the control circuit using contract drawings and approved vendor drawings. Close and open the contactor using all control devices. _____

DISTRIBUTION:

CONTRACTOR/Date _____

460 V MOTOR CIRCUIT (480 V MCC)
TEST RECORD

EQUIPMENT DESIGNATION			
MOTOR TAG NO.		VOLTAGE F.L.A.	
KW/HP		RPM	S.F.
CIRCUIT BREAKER MFG.		RATING	SETTING
STARTER MFG.		SIZE	O/L HTR. SIZE
C.T. RATIO		O/L RELAY SETTING	
CONDUCTOR SIZE	POWER	GROUND	

1. Check motor starter for cleanliness. _____

2. Check nameplate data and tagging of motor starter components for conformance to approved vendor drawings. _____

3. Check conduits and/or cables for correct tagging. _____

4. Check equipment and installation for conformance to area classification. _____

5. Check main and auxiliary contacts of breaker and contactors. _____

6. Manually check mechanical operation of breaker, contactor, O/L relay, and O/L reset device. _____

7. Check continuity of power and control cables. _____

8. Complete functional operation check of the motor control circuit using the contract drawings and approved vendor drawings. Close and open the starter using all control devices. _____

9. Verify proper operation of motor winding space heater unit. _____

DISTRIBUTION:

CONTRACTOR/Date _____

ELECTRIC MOTOR RUN-IN
TEST RECORD

TEST EQUIPMENT: _____ REFERENCE DRAWING: _____

NOTES: 1. Duration of tests to comply with specifications.

TEST	REMARKS	INITIALS/DATE
RESISTANCE: Bonding resistance measured from motor frame to main ground/earth system tap. _____ ohms		
VOLTAGE: Actual voltage measured at Motor Control Center. _____ volts		
ROTATION CHECK: Bump motor to verify rotation. Motor to be uncoupled.		
NO LOAD CURRENT: At beginning of test _____ amps At end of test _____ amps		
TEMPERATURE OF BEARING: Check bearing for high temperature: Before start: 15 minutes after start 30 minutes after start 1 hour after start 2 hours after start 3 hours after start		
VIBRATION: Make visual inspection during run-test. Record any unusual vibration in remarks column.		
NOISE: Record any unusual noise in remarks column.		

DISTRIBUTION:

CONTRACTOR/Date _____

THERMOGRAPHIC INSPECTION
TEST RECORD

EQUIPMENT: _____

THERMAL AND ELECTRICAL INFORMATION

THERMAL DATA (°F/°C) AND RISE				MANUAL READINGS			
A Phase	____/____	Reference	_____°F	A Phase	_____ A	A/ B Volts	_____V
B Phase	____/____	Temperature	_____° C	B Phase	_____ A	B/C Volts	_____V
C Phase	____/____	ΔT	_____°F	C Phase	_____ A	A/C Volts	_____V
Neutral	____/____	or Rise	_____° C	Neutral	_____ A	A/N Volts	_____V
ANOMALY TEMP(°F/°C)							
PROBLEM DESCRIPTION:							
RECOMMENDATION:							

ANOMALY PRIORITY

CRITICAL - IMMEDIATE ATTENTION SUGGESTED

SEVERE - PROBABLE FAILURE, PROMPT ACTION RECOMMENDED

INTERMEDIATE - MONITOR PROBLEM, SCHEDULE MAINTENANCE

MINOR - SCHEDULE ROUTINE MAINTENANCE AT NEXT OPPORTUNITY

DISTRIBUTION:

CONTRACTOR/Date _____

END OF SECTION

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SECTION 26 05 10
ELECTRIC MOTORS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General: The CONTRACTOR shall provide electric motors, accessories, and appurtenances complete and operable, in conformance to the Contract Documents.

B. The provisions of this Section apply to low voltage 3 phase, AC squirrel cage induction motors throughout the Contract Documents, except as indicated otherwise.

C. The CONTRACTOR shall assign to the equipment supplier the responsibility to select suitable electric motors for the equipment. The choice of motor manufacturer shall be subject to review by the ENGINEER. Such review will consider future availability of replacement parts and compatibility with driven equipment

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Complete motor data shall be submitted with the driven machinery Shop Drawings. Motor data shall include:

1. Machine name and specification number of driven machine
2. Motor manufacturer
3. Motor type or model and dimension drawing. Include motor weight.
4. Nominal horsepower
5. NEMA design
6. Enclosure
7. Frame size
8. Winding insulation class and temperature rise class
9. Voltage, phase, and frequency ratings
10. Service factor
11. Full load current at rated horsepower for application voltage
12. Full load speed

13. Guaranteed minimum full load efficiency. Also nominal efficiencies at 1/2 and 3/4 load.

14. Type of thermal protection or overtemperature protection, where included

15. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable

16. Bearing data. Include recommendation for lubricants of relubricatable type bearings.

17. If utilized with a variable frequency controller, verify motor is inverter duty type. Include minimum speed at which motor may be operated for the driven machinery. Provide shaft grounding details and information. Provide insulated bearing details and information.

18. Power factor at 1/2, 3/4 and full load.

19. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.

C. If water cooling is required for motor thrust bearings, the Shop Drawing submittals shall indicate this requirement.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electric motors driving identical machines shall be identical.

B. Maximum motor loading shall be equal to nameplate horsepower rating or less, exclusive of service factor and be verifiable from the submittal data of the driven machinery.

C. Motor Capacity

1. The CONTRACTOR shall size motors for the larger of the following criteria:

a. Size motors to continuously carry the maximum load that develops across the full range of driven equipment operation.

b. Size motors for minimum size indicated

2. In every case, motor size shall be derated from nameplate values as follows:

a. Ambient Temperature

1) For ambient temperatures up to but not exceeding 40 degrees C, no derating is required.

2) For ambient temperatures exceeding 40 degrees but less than 50 degrees C, derate nameplate HP ratings to 85 percent.

b. Site Altitude: No derating is required for altitudes less than 3300 feet (1000 meters). Higher altitudes require the following derating factors:

Altitude	Derating Factor
3,300 to 5,000 ft	97 percent
5,001 to 6,600 ft	94 percent
6,601 to 8,300 ft	91 percent
8,301 to 9,900 ft	88 percent
9,901 to 11,500 ft	85 percent

3. Increased circuit breaker, magnetic starter, and conductor and conduit capacities required for motors larger than the indicated sizes shall be provided as part of the WORK.

D. Exempt Motors: Motors for valve operators, submersible pumps, or motors which are an integral part of standard manufactured equipment, i.e., non-NEMA mounting, common shaft with driven element, or part of domestic or commercial use apparatus may be excepted from these requirements to the extent that such variation reflects a necessary condition of motor service or a requirement of the driven equipment.

2.2 DESIGN REQUIREMENTS

A. General: Electric motors shall comply with NEMA MG-1 - Motor and Generator. Motors used with adjustable frequency drives shall comply with NEMA MG-1, Part 31, and shall be clearly identified as "Inverter Duty."

B. NEMA Design: Electric motors shall be NEMA Design B unless otherwise indicated. In no case shall starting torque or breakdown torque be less than the value in NEMA MG 1. Motors shall be suitable for the indicated starting method.

C. Motor Voltage Ratings: Low voltage motors shall have voltage ratings in accordance with the following, unless otherwise indicated:

1. Motors below 1/2 HP shall be rated 115 volts, single phase, 60 Hz. Dual voltage motors rated 115/230 volts, 115/208 volts, or 120-240 volts are acceptable, provided leads are brought out to the conduit box.

2. Motors 1/2 HP and larger shall be rated 460 volts, 3 phase, 60 Hz. Dual voltage motors rated 230/460 volts or 208/230/460 volts are acceptable, provided every lead is brought out to the conduit box.

D. Insulation: Three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors

will be installed and operated, without exceeding Class B temperature rise limits stated in NEMA MG 1-12.44. Single phase motors shall have Class F insulation with temperature rise not to exceed the insulation class. Motors to be operated from adjustable frequency drives shall be provided with insulation systems to withstand 1600 volt spikes, with dV/dT as defined in NEMA MG 1-31. The adjustable frequency drive manufacturer shall coordinate with the motor manufacturer to determine when additional dV/dT protection is required. Where required, it shall be furnished and installed as per the manufacturer's written instructions.

E. Motors 50 HP or smaller located in non-hazardous areas shall be totally enclosed, fan cooled (TEFC) with a Service Factor of 1.15 for non-VFD applications and service factor of 1.15 (sine)/1.0 (inverter) for VFD applications.

F. Motors 50 HP and greater located in non-hazardous areas shall be TEFC, with a service factor of 1.15 for non-VFD applications and service factor of 1.15 (sine)/1.0 (inverter) for VFD applications.

G. Motors for use in hazardous locations shall have enclosures suitable for the classification indicated. Such motors shall be U.L. listed and be stamped as such.

H. Motors larger than 50 HP or where indicated shall be provided with 120 volt AC space heaters, wired to a terminal strip in a low voltage motor junction box. If provided by the manufacturer when not specified, the manufacturer shall not require that they be connected or the CONTRACTOR shall connect them at no extra cost to the OWNER, in order to keep the warranty in force.

I. NEMA Premium Efficiency Motors

1. Motors with a nameplate rating of 1 HP and larger shall be NEMA premium efficient units. Motors shall be stamped with the efficiency on the nameplate with the caption "NEMA Nominal Efficiency" or "NEMA Nom. Eff." Such motors shall have efficiencies determined by the test as set forth in ANSI/IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators, Method B.

2. Efficiency: Nominal efficiency and minimum efficiency shall be defined in accordance with the following tables. Both efficiencies shall be included in the Shop Drawing submittal.

OPEN DRIP-PROOF (ODP)						
FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS RATED 600 VOLTS OR LESS						
	2 POLE		**4 POLE**		**6 POLE**	
HP	**Nom. Effic.**	**Min. Effic.**	**Nom. Effic.**	**Min. Effic.**	**Nom. Effic.**	**Min. Effic.**
1	77.0	74.0	85.5	82.5	82.5	80.0
1.5	84.0	81.5	86.5	84.0	86.5	84.0
2	85.5	82.5	86.5	84.0	87.5	85.5
3	85.5	82.5	89.5	87.5	88.5	86.5
5	86.5	84.0	89.5	87.5	89.5	87.5
7.5	88.5	86.5	91.0	89.5	90.2	88.5
10	89.5	87.5	91.7	90.2	91.7	90.2
15	90.2	88.5	93.0	91.7	91.7	90.2
20	91.0	89.5	93.0	91.7	92.4	91.0
25	91.7	90.2	93.6	92.4	93.0	91.7
30	91.7	90.2	94.1	93.0	93.6	92.4
40	92.4	91.0	94.1	93.0	94.1	93.0
50	93.0	91.7	94.5	93.6	94.1	93.0
60	93.6	92.4	95.0	94.1	94.5	93.6
75	93.6	92.4	95.0	94.1	94.5	93.6
100	93.6	92.4	95.4	94.5	95.0	94.1
125	94.1	93.0	95.4	94.5	95.0	94.1
150	94.1	93.0	95.8	95.0	95.4	94.5
200	95.0	94.1	95.8	95.0	95.4	94.5
250	95.0	94.1	95.8	95.0	95.8	95.0
300	95.4	94.5	95.8	95.0	95.8	95.0
350	95.4	94.5	95.8	95.0	95.8	95.0
400	95.8	95.0	95.8	95.0	--	--
450	96.2	95.4	96.2	95.4	--	--
500	96.2	95.4	96.2	95.4	--	--

Source: NEMA MG1 - 2011, Table 12-12

TOTALLY ENCLOSED - FAN COOLED (TEFC)						
FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS RATED 600 VOLTS OR LESS						
	2 POLE		**4 POLE**		**6 POLE**	
HP	**Nom. Effic.**	**Min. Effic.**	**Nom. Effic.**	**Min. Effic.**	**Nom. Effic.**	**Min. Effic.**
1	77.0	74.0	85.5	82.5	82.5	80.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5
2	85.5	82.5	86.5	84.0	88.5	86.5
3	86.5	84.0	89.5	87.5	89.5	87.5
5	88.5	86.5	89.5	87.5	89.5	87.5
7.5	89.5	87.5	91.7	90.2	91.0	89.5
10	90.2	88.5	91.7	90.2	91.0	89.5
15	91.0	89.5	92.4	91.0	91.7	90.2
20	91.0	89.5	93.0	91.7	91.7	90.2
25	91.7	90.2	93.6	92.4	93.0	91.7
30	91.7	90.2	93.6	92.4	93.0	91.7
40	92.4	91.0	94.1	93.0	94.1	93.0
50	93.0	91.7	94.5	93.6	94.1	93.0
60	93.6	92.4	95.0	94.1	94.5	93.6
75	93.6	92.4	95.4	94.5	94.5	93.6
100	94.1	93.0	95.4	94.5	95.0	94.1
125	95.0	94.1	95.4	94.5	95.0	94.1
150	95.0	94.1	95.8	95.0	95.8	95.0
200	95.4	94.5	96.2	95.4	95.8	95.0
250	95.8	95.0	96.2	95.4	95.8	95.0
300	95.8	95.0	96.2	95.4	95.8	95.0
350	95.8	95.0	96.2	95.4	95.8	95.0
400	95.8	95.0	96.2	95.4	--	--
450	95.8	95.0	96.2	95.4	--	--
500	95.8	95.0	96.2	95.4	--	--

Source: NEMA MG1 - 2011, Table 12-12

J. Two speed motors shall be of the 2 winding type.

2.3 ACCESSORY REQUIREMENTS

A. General: Horizontal motors 3 HP and larger and every vertical motor shall have split-type cast metal conduit boxes. Motors shall be provided with oversized conduit boxes. Where conduit sizes indicated do not match the motor terminal box, the CONTRACTOR shall provide means to accommodate the motor requirements. Motor boxes other than open drip-proof shall be gasketed.

B. Lifting Devices: Motors weighing 265 lb (120 Kg) or more shall have suitable lifting eyes for installation and removal.

C. Special Requirements: The CONTRACTOR shall refer to individual equipment specifications for special requirements such as motor winding thermal protection or multi-speed windings.

D. Grounding Lugs: Provide motor grounding lug suitable to terminate ground wire, sized as indicated.

E. Nameplate: Motors shall be fitted with permanent stainless steel nameplates indelibly stamped or engraved with NEMA Standard motor data, in conformance with NEMA MG-1-10.40. Inverter duty motors shall be clearly identified as such.

F. Where motors are indicated by elementary schematics or specifications to have zero speed switches, the switches shall be factory mounted integral to the motors. Switches shall close the contacts when the motor is at zero speed.

G. Inverter duty motors shall be provided with shaft grounding rings. Rings shall be factory installed, and shall be manufactured by **Aegis**, or equal. The motor warranty shall include coverage against VFD-induced bearing damage or failure.

2.4 MOTOR THERMAL PROTECTION

A. Single Phase Motors: Single phase 120, 208, or 230 volt motors shall have integral thermal overload protection or shall be inherently current limited.

B. Thermostats: Where indicated or specified, winding thermostats shall be snap action, bi-metallic, temperature-actuated switch. Thermostats shall be provided with one normally closed contact. The thermostat switch point shall be precalibrated by the manufacturer. All inverter duty motors shall be provided with winding thermostats, unless RTDs are specified. All explosion-proof motors shall be provided with winding thermostats.

2.5 MOTOR BEARINGS

A. General: Bearings shall conform to Section 11 00 00 - Equipment General Provisions, except as indicated herein.

B. Motors greater than 2 HP shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.

C. Fractional Horsepower: Motors with fractional horsepower through 2 HP shall be provided with lubricated-for-life ball bearings.

D. Horizontal Motors Over 2 HP: Motors larger than 2 HP shall be provided with relubricatable ball bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.

E. Vertical Motors Over 2 HP: Vertical motors larger than 2 HP shall be provided with relubricatable ball, spherical, roller, or plate type thrust bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.

F. Water Cooled Motors: If water cooling is required for the thrust bearings, cooling water lines shall be provided complete with shut-off valve, strainer, solenoid valve, flow indicator, thermometer, throttling valve, and, (where subject to freezing), insulation with heat tracing.

G. Inverter Duty Motors: Provide an insulated bearing to prevent circulating bearing currents.

2.6 MANUFACTURERS, OR EQUAL

A. **U.S. Motors/Nidec**

B. **Baldor**

C. **WEG**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment. Shaft grounding devices shall be connected to the grounding system in accordance with the manufacturer’s recommendations.

B. Related electrical WORK involving connections, controls, switches, and disconnects shall be performed in accordance with the applicable sections of Division 26.

3.2 FACTORY TESTING

A. Motors rated 100 HP and larger shall be factory tested in conformance with IEEE 112, IEEE 43 - Recommended Practice for Testing Resistance of Rotating Machinery, and NEMA MG-2. Except where specific testing or witnessed shop tests are required by the specifications for driven equipment, factory test reports may be copies of routine test reports of electrically duplicate motors. Test report shall indicate test procedure and instrumentation used to measure and record data. Test report shall be certified by the motor manufacturer's test personnel and be submitted to the ENGINEER.

3.3 FIELD TESTING

A. The CONTRACTOR shall perform the following field tests (see also Section 26 01 26 – Electrical Testing):

1. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.

2. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage. Verify shaft grounding devices are properly grounded.

3. Check winding and bearing temperature detectors and space heaters for functional operation.

4. Test for proper rotation prior to connection to the driven equipment.

5. Visually check that motor overload heaters are properly sized and that MCP breaker settings are correct for the motor installed.

6. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of the motor.

END OF SECTION

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SECTION 26 05 15
INDUSTRIAL CONTROL PANELS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide complete industrial control panels and/or local control stations as indicated herein or in other Sections of the Specifications. The stations shall be designed to provide the sequence of operation in Section 40 91 00 – Process Control and Instrumentation Systems and the P&ID Drawings.

B. This section also specifies miscellaneous electrical devices used throughout this project. These devices are not limited to use within industrial control panels or local control stations.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Industrial control panels and/or local control stations shall comply with the requirements of NEC (including Article 409), NEMA, and UL.

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings in accordance with Sections 01 33 00 – Contractor Submittals and 26 00 00 – Electrical Work, General.

1. Ladder diagrams and written descriptions explaining ladder diagram operation and system operation.

2. Include catalog cuts of control equipment including enclosures, overcurrent devices, relays, pilot devices, terminations, and wire troughs.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide the equipment, panels and stations to satisfy the functional requirements in the relevant mechanical equipment and Instrumentation and Control specifications and the Electrical Elementary Schematics. Each panel and station shall be fabricated with UL labeled components. Equipment not specifically indicated as being WORK of other Sections shall be provided under this Section. All equipment, panels and stations shall be wired under this Section.

B. The controls shall be 120 V maximum. Where the electrical power supply is 240 V, single phase or 480 V, 3 phase, the station shall be provided with a fused control power transformer. Control conductors shall be provided in accordance with Section 26 05 19 – Wire and Cabling.

C. Each panel and/or station shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use. Termination points shall be identified in accordance with Shop Drawings. The panels and/or stations shall be the source of power for all 120 VAC solenoid valves interconnected with the panels and/or stations. Equipment associated with the panels and/or stations shall be ready for service after connection of conductors to equipment, controls, panels and/or stations.

D. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental personnel contact with energized terminals.

E. Enclosures

1. In finished rooms, enclosures shall be NEMA 12 steel enclosures painted with ANSI 61 exterior and white interior.

2. In all other non-hazardous areas, enclosures shall be NEMA 4X stainless steel with brushed finish. Where possible, penetrations shall be made in such a manner to maintain the NEMA 4X rating. If this is not possible, the penetrations shall be made in such a manner to minimize entry of foreign materials into the enclosure, subject to approval by the ENGINEER.

3. In hazardous areas, enclosures shall be cast aluminum NEMA 7 and shall be UL listed for use in hazardous or classified locations.

4. In chemical areas for alum, sodium hypochlorite, etc., NEMA 4X fiberglass enclosures shall be used.

5. Enclosures shall be freestanding, pedestal-mounted, or equipment skid-mounted, as indicated. Internal control components shall be mounted on a removable mounting pan. Mounting pan shall be finished white.

6. Provide screened weep holes for draining condensation.

F. Disconnect Switches

1. Heavy duty, fusible, single throw switches shall be rated not less than 65 KA at 480 VAC.

2. Horsepower rated

3. UL listed

4. Padlockable in "Off" position and door interlock

5. Enclosure per area classification in Section 26 00 00 – Electrical Work, General.

6. 480 V, 3-phase, 3-pole (6-pole when used with 2-speed motor).

7. Auxiliary control contact as applicable and where indicated.

8. As manufactured by **G.E., Eaton Electrical, Square D,** or equal.

G. Identification of panel-mounted devices, conductors, and electrical components shall be in accordance with Section 26 00 00 – Electrical Work, General.

H. Panel-mounted devices shall be mounted a minimum of 3-feet above finished floor elevation, but not higher than 6'-6" above finished floor, unless noted otherwise.

2.2 PANEL/STATION COMPONENTS

A. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30-mm. Miniature style devices are not acceptable. Devices shall be as manufactured by **General Electric, Eaton Electrical, Square D,** or equal.

1. Lens colors shall be red for "run," "open," or "on"; green for "stopped," "closed," or "off"; and amber for alarm.

2. Pilot lights shall be full voltage, push-to-test, LED cluster type.

3. Provide hazardous location type pilot devices in classified locations.

B. Relays shall be 3 PDT with 10 amp contacts, plug-in type with indicating light, rectangular blades and provided with sockets for screw-type termination and hold-down clips. Relays shall be as manufactured by **Square D, Potter Brumfield,** or equal.

C. Elapsed time meters shall be non-resettable type, read to a maximum of 99999.9 hours and shall be as manufactured by **General Electric, Eaton Electrical,** or equal.

D. Magnetic starters shall be:

1. NEMA rated, Size 1 minimum. IEC or dual NEMA/IEC rated type are not acceptable.

2. FVNR type unless indicated otherwise.

3. Combination starters with magnetic only instantaneous trip circuit breakers such as **Eaton Electrical HMCP, General Electric Mag-Break,** or equal. Breakers shall be rated 65 KA minimum.

4. Control transformers shall be provided with primary and secondary fuses, 120 V maximum control voltage. VA rating of transformer shall be based on devices on the control schematic.

E. Terminal strips shall be provided for every panel and shall be the flanged fork or ring lug type suitable for No. 12 AWG stranded wire minimum. Provide 25 percent spare terminals in each panel.

F. Time delay relays shall be combination on delay and off delay (selectable) with adjustable timing ranges. Provide socket with screw terminal connections and retaining strap. Time delay relays shall be **Square D, ATC, Eaton Electrical,** or equal.

2.3 FACTORY TESTING

A. Each panel/station shall be factory assembled and tested for sequence of operation prior to delivery.

2.4 SPARE PARTS

A. Provide a minimum of 10 percent spare lamps (minimum 2) and one spare lens for each color pilot lamp in each panel.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Panels/stations shall be installed in accordance with in Section 26 00 00 – Electrical Work, General and in accordance with the manufacturer's recommendations.

B. Panels/stations shall be protected at the site from loss, damage, and the effects of weather. Panels/stations shall be stored in an indoor, dry location. Heating shall be provided in areas subject to corrosion and humidity.

C. Panels/station interiors and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the WORK.

D. Conduit, conductors, and terminations shall be installed in accordance with Section 26 00 00 – Electrical Work, General.

3.2 FIELD TESTING

A. Each panel/station shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

END OF SECTION

SECTION 26 05 19
WIRE AND CABLING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide wire and cable, complete and operable, in accordance with the Contract Documents.

B. In the event that motors provided are larger horsepower than the motors indicated, raceways, conductors, starters, overload elements, and branch circuit protectors shall be revised as necessary to control and protect the increased motor horsepower in accordance with Section 26 05 10 – Electric Motors. Revisions are part of the WORK of this Section.

1.2 ACTION SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings in accordance with Sections 01 33 00 – Contractor Submittals and 26 00 00 – Electrical Work, General. Submit cable test results in accordance with this Section .

1.3 DELIVERY, STORAGE AND HANDLING

A. The CONTRACTOR shall protect all cables from damage at all times.

B. Cable ends shall be protected from water entry in accordance with the manufacturer's recommended procedures. Cable ends shall not be left open in manholes or other locations subject to submergence. If the cable ends become submerged prior to splicing or termination, the cables shall be replaced in their entirety.

C. Cables shall be pulled into raceways in accordance with the manufacturer's requirements. Under no circumstances shall cable pulling tensions exceed the manufacturer's written instructions.

D. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

PART 2 -- PRODUCTS

EQUIPMENT

A. Conductors, include grounding conductors, shall be stranded copper. Aluminum conductor and/or solid conductor wire and cable will not be permitted. Insulation shall bear the UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code, latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article 400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.

B. Low Voltage Power and Lighting Wire

1. Wire rated for 600 volts in duct or conduit for power and lighting circuits shall be single conductor, Class B Type XHHW or XHHW-2 cross-linked polyethylene conforming to UL-44 - UL Standard for Thermoset-Insulated Wires and Cables. THHN/THWN wire shall not be permitted to be used for any power or control wiring in this project, except as specifically permitted within control panels per Section 40 95 13 – Control Panels.

2. Conductors for feeders as defined in Article 100 of the NEC shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

3. Conductors for branch circuits as defined in Article 100 of the NEC shall be sized to prevent voltage drop exceeding 3 percent at the farthest connected load or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

4. Wiring for 600 volt class power and lighting shall be as manufactured by **Okonite**, **General Cable**, **Southwire**, or equal.

C. Low Voltage Control Wire

1. Low voltage control wire in duct or conduit shall be the same type as power and lighting wire indicated above.

2. Control wiring shall be No.14 AWG.

3. Control wires inside panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations, and be as manufactured by **American, General Cable,** or equal.

D. Instrumentation Cable

1. Instrumentation cable shall be rated at 300 volts, minimum.

2. Individual conductors shall be No. 16 AWG stranded, tinned copper. Insulation shall be color coded polyethylene: black-clear for 2 conductor cable and black-red-clear for 3 conductor cable.

3. Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 18 or larger AWG stranded, tinned copper drain wire, and a PVC outer jacket with a thickness of 0.047-inches.

4. Single pair, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8719,** similar by **General Cable,** or equal.

5. Single triad, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8618,** similar by **General Cable,** or equal.

E. VFD Power Cable

1. VFD power cable shall be three (3) conductor, stranded copper, PVC jacketed, shielded type, tray cable (TC) rated 600 volts with three (3) symmetrical ground conductors. The individual conductors shall be UL listed as Type XHHW-2 or RWH-2 rated for 90 degrees C at wet and dry locations, with XLPE insulation.

2. VFD Cables shall be as manufactured by **Belden, Alpha**, **General Cable,** or equal.

F. Cable Splices and Terminations

1. Where cable lugs are required for power cable terminations, utilize compression lugs – **3M** Scotchlok 30000 and 31100 Series, **Penn Union** HBBLU and BLU, **Burndy** Hylug, or equal. Utilize compression tools as recommended by the manufacturer. Pressure type, twist-on connectors (wire nuts) will not be acceptable.

2. Pre-insulated fork tongue lugs shall be **Thomas & Betts, Burndy**, or equal.

3. General purpose insulating tape shall be **Scotch No. 33**, **Plymouth Slip-knot**, or equal. High temperature tape shall be polyvinyl as manufactured by **Plymouth, 3M,** or equal.

4. Labels for coding 600 volt wiring shall be computer printable or pre-printed, self-laminating, self-sticking, as manufactured by **W.H. Brady, 3M**, or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall provide, terminate and test all power, control, and instrumentation conductors.

B. The CONTRACTOR shall, as a minimum, provide the number of control wires listed in the conduit schedule or on the Contract Drawings. Excess wires shall be treated as spares for future use.

C. Conductors shall not be pulled into any raceway until raceway has been cleared of moisture and debris.

D. Instrumentation wire shall not be run in the same raceway with power and control wiring except where specifically indicated.

E. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be neatly fanned out to terminals.

F. Single conductor cable in cable trays shall be No. 1/0 or larger and shall be of a type listed and marked for use in cable trays. Tray cable smaller than 1/0 shall be multi-conductor, with outer jacket.

3.2 FIELD ASSEMBLY

A. General

1. Wire taps and splices shall be properly taped and insulated according to their respective classes.

2. In general, there shall be no cable splices in underground manholes or pullboxes. If splices are necessary, the cables shall be spliced using submersible cable splices, suitable for continuous submergence. Splices in underground manholes and pullboxes may be made only with the approval of the ENGINEER.

3. Stranded conductors shall be terminated directly on equipment box lugs making sure that conductor strands are confined within lug. Use forked-tongue lugs where equipment box lugs have not been provided.

4. Excess control and instrumentation wires shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified with origin, and be neatly coiled.

B. Control Wire and Cable

1. Control conductors shall be spliced or terminated only at the locations indicated and only on terminal strips or terminal lugs of vendor furnished equipment.

2. In motor control centers, and control panels, control wire and spare wire shall be terminated to terminal strips.

3. The CONTRACTOR shall provide as a minimum the number of control wires listed in the conduit schedule or as indicated in the Contract Documents. Excess wires shall be treated as spares.

C. Instrumentation Wire and Cable

1. Shielded instrumentation cables shall be grounded at one end only, preferably the receiving end on a 4 - 20 mA system.

2. Two and 3 conductor shielded cables installed in conduit runs which exceed available standard cable lengths may be spliced in pullboxes with the prior approval of the ENGINEER. Such cable runs shall have only one splice per conductor.

D. Power Wire and Cable

1. 120/208-volt, 120/240-volt, and 480/277-volt branch circuit conductors may be spliced in suitable fittings at locations determined by the CONTRACTOR. Cables rated above 2,000 volts shall be spliced or terminated only at equipment terminals indicated.

2. Splices to motor leads in motor terminal boxes shall be wrapped with mastic material to form a mold and then shall be taped with a minimum of 2 layers of varnished cambric tape overtaped with a minimum of 2 layers of high temperature tape.

3. Shielded power cable shall be terminated with pre-assembled stress cones in a manner approved by the cable and terminal manufacturer. The CONTRACTOR shall submit the proposed termination procedure as a Shop Drawing.

4. VFD shielded power cables shall have the shield grounded at all locations where it is exposed.

E. Cable Identification

1. General: Wire and cable shall be identified for proper control of circuits and equipment and to reduce maintenance effort. Identification shall be installed at every termination point.

2. Identification Numbers: The CONTRACTOR shall assign to each control and instrumentation wire and cable a unique identification number. Numbers shall be assigned to conductors having common terminals and shall be shown on "as built" drawings. Identification numbers shall appear within 3-inches of conductor terminals. "Control and Instrumentation Conductors" shall be defined as any conductor used for control, interlock, alarm, annunciator, or signal purposes.

   a. Multiconductor cable shall be assigned a number which shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment. It is expected that the cable number shall form a part of the individual wire number. Individual control conductors and instrumentation cable shall be identified at pull points as described above. The instrumentation cable numbers shall incorporate the loop numbers assigned in the Contract Documents.

   b. 120/208-volt system feeder cables and branch circuit conductors shall be color coded as follows: Phase A - black, Phase B - red, Phase C - blue, and Neutral - white. The 480/277-volt system conductors shall be color coded as follows: Phase A - Brown, Phase B - Orange, Phase C - Yellow, and Neutral - Gray. Branch circuit switch shall be yellow. Insulated ground wire shall be green, and neutral shall be gray. Color coding and phasing shall be consistent throughout the Site, but bars at panelboards, switchboards, and motor control centers shall be connected Phase A-B-C, top to bottom, or left to right, facing connecting lugs. Color coding tape shall be used where colored insulation is not available. Colored identification tape may be used on conductors between the local disconnect and the load, where permitted by the NEC. Any phase changes necessary for proper rotation shall be made at the driven equipment where colored insulation is used. Phase changes may be made on the load side of the local disconnect, where phase colors are identified using tape.

   c. General purpose AC control cable shall be red. General purpose DC control cable shall be blue.

   d. Spare cable shall be terminated on terminal screws and shall be identified with a unique number as well as with destination.

   e. Terminal strips shall be identified by computer printable, cloth, self-sticking marker strips attached under the terminal strip.

3.3 FIELD QUALITY CONTROL

A. Cable Assembly and Testing: Cable assembly and testing shall comply with applicable requirements of ICEA Publication No. S-95-658/NEMA WC70 - Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy. Factory test results shall be submitted in accordance with Section 01 33 00 – Contractor Submittals, prior to shipment of cable. The following field tests (in addition to the tests specified in Section 26 01 26 – Electrical Tests) shall be the minimum requirements:

1. Insulation resistance testing, using a DC megohmeter, shall be performed on cables operating at more than 2,000 volts to ground. Time-resistance readings shall be taken and recorded at intervals of 30 seconds and one minute. Time-resistance voltage levels shall be per the cable manufacturer's recommendations.

2. Power cable rated at 600 volts shall be tested for insulation resistance between phases and from each phase to a ground using a megohmeter.

3. Field testing shall be done after cable is installed in the raceways.

4. Field tests shall be performed by a NETA-certified test organization. Test results shall be submitted to the ENGINEER for review and acceptance.

5. Cables failing the tests shall be replaced with a new cable or be repaired. Repair methods shall be as recommended by the cable manufacturer and shall be performed by persons certified by the industry.

B. Continuity Test: Control and instrumentation cable shall be tested for continuity, polarity, undesirable ground, and origination. Such tests shall be performed after installation and prior to placing cable in service.

END OF SECTION

SECTION 26 05 26
GROUNDING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide the electrical grounding system, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 – Electrical Work, General apply to this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 ACTION SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals and Section 26 00 00 – Electrical Work, General.

1. Include with each submittal a copy of this specification section, with addenda updates included, and all referenced and applicable sections included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

B. Shop Drawings

1. Submit manufacturer's product information for connectors, clamps, and all grounding system components, showing compliance with the requirements of this Section.

PART 2 -- PRODUCTS

2.1 EQUIPMENT

A. Components of the grounding electrode system shall be manufactured in accordance with UL 467 - Standard for Safety Grounding and Bonding Equipment, and shall conform to the applicable requirements of National Electrical Code Article 250 and local codes.

B. Grounding System

1. Grounding loop conductors shall be bare annealed copper conductors.

2. Conductors shall be No. 4/0 unless indicated otherwise.

3. Ground Rods

   a. Unless indicated otherwise, provide ground rods minimum of 3/4 inch in diameter, 10 feet long, and with a uniform covering of electrolytic copper metallically bonded to a rigid steel core.

   b. Provide corrosion-resistant copper-to-steel bond.

   c. The rods shall conform to UL 467.

   d. The rods shall be of the sectional type, joined by threaded copper alloy couplings.

4. Make buried, concrete-encased, or otherwise inaccessible cable-to-cable and cable-to-ground rod connections using exothermic welds by **Cadweld, Thermoweld,** or equal.

5. Exposed Connectors

   a. Exposed grounding connectors shall be of the compression type (connector-to-cable), constructed of high-copper alloy, and manufactured specifically for the particular grounding application.

   b. The connectors shall be **Burndy, O.Z. Gedney**, or equal.

6. Use grounding clamps to bond each separately-derived system to the grounding electrode conductors.

7. Equipment Grounding Circuit Conductors

   a. The conductors shall be the same type and insulation as the load circuit conductors.

   b. The minimum size shall be as indicated. Where not indicated, sizes shall conform to Table 250.122 of the National Electrical Code.

   c. Metallic conduit systems shall have an equipment grounding wires as well as being equipment grounding conductors themselves.

8. Grounding Materials Manufacturer, or Equal

   a. Copperweld

   b. Thermoweld

   c. Burndy

d. Thomas and Betts

e. **OZ Gedney**EXECUTION

2.2 PREPARATION

A. Provide a separate grounding conductor, securely grounded in each raceway independent of raceway material.

B. Provide a separate grounding conductor for each motor and connect at motor box. Provide a supplemental ground connection for motor shaft grounding rings, where applicable.

C. Do not use bolts for securing the motor box to the frame or the cover for grounding connectors.

D. Sizes shall be as indicated on the Conduit Schedule and in accordance with NEC Article 250.

E. Route the conductors inside the raceway.

F. Provide a grounding-type bushing for secondary feeder conduits that originate from the secondary section of each MCC section, switchboard, or panelboard.

G. Individually bond the raceway to the ground bus in the secondary section.

H. Provide a green insulated wire as grounding jumper from the ground screw to a box grounding screw, and, for grounding type devices, to the equipment grounding conductor.

I. Provide a separate grounding conductor in each individual raceway for parallel feeders. Connect the parallel ground conductors together at each end of the parallel run, as required by the NEC.

J. Interconnect the secondary switchgear MCC or panelboard neutral bus to the ground bus in the secondary switchgear compartment only at the service entrance point. For wye connected, 3 phase, separately derived systems with 3 wire distribution, connect the transformer neutral to the grounding electrode system at the transformer. Connections shall be in accordance with the NEC.

K. Provide the duct bank ground system as indicated, including trenching, splices, ground rods, and connections to equipment and structures.

L. Measure ground impedance in accordance with IEEE STD 81 after installation but before connecting the electrode to the remaining grounding system. Provide additional grounding system testing in accordance with Section 26 01 26 – Electrical Tests.

M. Low Voltage Grounded System (600V or less)

1. A low-voltage grounded system is defined as a system where the local power supply is a transformer, with the transformer secondary grounded.

2. Grounding system connections for a premises-wired system supplied by a grounded AC service shall be provided with a grounding electrode connector connected to the grounded service conductor at each service, in accordance with the NEC.

3. The grounded circuit conductor shall not be used for grounding non-current-carrying parts of equipment, raceways, and other enclosures except where specifically listed and permitted by the NEC.

N. Embedded Ground Connections

1. Underground and grounding connections embedded in concrete shall be UL-listed ground grid connectors.

2. The connection shall be made in accordance with the manufacturer's instructions.

3. Do not conceal or cover ground connections until the ENGINEER or an authorized representative has established that every grounding connection conforms to the requirements of the Contract Documents and has given the CONTRACTOR written confirmation.

O. Ground Ring

1. Furnish trenching and materials as necessary to install the ground ring as indicated.

2. The bonding conductor shall be in direct contact with the earth and of the indicated size.

3. Provide a minimum burial depth of 36 inches or as indicated on the Drawings, whichever is greater.

4. Re-compact disturbed soils to their original density in 6-inch lifts.

P. Ground Rods

1. Provide ground rods at the indicated locations.

2. A single electrode that does not have resistance-to-ground of 5 ohms or less shall be augmented by additional electrodes to obtain this value.

3. Take the resistance-to-ground measurement during dry weather, a minimum of 48 hours after a rainfall.

4. Rods forming an individual ground array shall be equal in length.

Q. Instrumentation Shield Grounding

1. Shielded instrumentation cable shall have its shield grounded at one end only unless the approved Shop Drawings indicate that the shield will be grounded at both ends.

2. The grounding point shall be at the control panel or at the receiving end of the signal carried by the cable.

3. The termination of the shield drain wire shall be on its own terminal screw.

4. Jumper together the terminal screws, using manufactured terminal block jumpers or a No. 14 green insulated conductor.

5. Connect the ground bus via a green No. 12 conductor to the main ground bus for the panel.

END OF SECTION

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SECTION 26 05 33
ELECTRICAL RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide electrical raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. In the event that individual equipment loads provided are larger than indicated in the Contract Documents, revise raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased connected load in conformance to NEC requirements as part of the WORK.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals, and Section 26 00 00 – Electrical Work, General.

B. Shop Drawings

1. Submit complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.

2. Submit dimensioned layout drawings of proposed embedded/encased raceway routings within concrete slabs.

3. Submit dimensioned layout drawings of cable tray routings, including elevations.

4. As-Built Drawings

a. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Pull and junction boxes, fittings, and other indicated enclosures that are dedicated to the raceway system shall comply with the requirements of this Section.

2.2 CONDUIT

A. Rigid Aluminum (RAL) Conduits

1. Provide rigid aluminum conduit manufactured from 6063 alloy, temper T-1.

2. Provide rigid aluminum conduit manufactured in accordance with NEMA C80.5 – Electrical Rigid Aluminum Conduit, and UL-6A – Electrical Rigid Metal Conduit - Aluminum, Red Brass and Stainless Steel.

3. Manufacturer, or Equal

    a. **V.A.W. of America**

    b. **Alcoa**

B. Rigid Galvanized Steel (RGS) Conduit

1. Provide rigid steel conduit manufactured from mild steel, hot-dip galvanized inside and out.

2. Provide rigid steel conduit manufactured in accordance with NEMA C80.1 – Electrical Rigid Steel Conduit, and UL-6 – Electrical Rigid Metal Conduit - Steel.

3. Manufacturer, or Equal

    a. **Allied Tube & Conduit**

    b. **Triangle**

    c. **Wheatland Tube**

C. PVC Rigid Non-Metallic Conduit

1. Provide rigid non-metallic conduit manufactured from Schedule 40 PVC, as indicated, and sunlight-resistant.

2. Provide rigid non-metallic conduit manufactured in accordance with NEMA TC-2 - Electrical Plastic Tubing and Conduit, and UL-651 - Standard for Rigid Non-metallic Conduit.

3. Manufacturer, or Equal

    a. **Carlon**

    b. **Cantex**

D. Rigid PVC-Coated Galvanized Steel (RPGS) Conduit

1. The conduit shall meet the requirements for RGS conduit as indicated above.

2. Bond a PVC coating to the outer surface of the galvanized conduit.

3. Ensure that the bond between the coating and the conduit surface is greater than the tensile strength of the coating.

4. Provide the inside surfaces and threads of the conduit with a 2-mil urethane coating.

5. Provide a PVC coating thickness not less than 40 mils.

6. The PVC-coated RGS shall be manufactured in accordance with the following standards:

    a. UL-6

    b. ANSI C80.1

    c. NEMA RN1 - PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

7. Manufacturer, or Equal

    a. **Robroy Industries**

    b. **O'Kote**

    c. **Thomas & Betts**

E. Liquid-Tight Flexible Conduit

1. Provide liquid-tight flexible conduit constructed of a flexible galvanized metal core with a sunlight-resistant thermoplastic outer jacket.

2. Provide liquid-tight flexible conduit manufactured in accordance with the requirements of UL-360 - Steel Conduits, Liquid-Tight Flexible.

3. Manufacturer, or Equal

    a. **Anaconda, Sealtite**

    b. **Electriflex, Liquatite**

F. Electrical Metallic Tubing (EMT) or Intermediate conduit (IMC) will not be accepted.

2.3 FITTINGS AND BOXES

A. General

1. For use with metallic conduit, provide cast and malleable iron fittings of the threaded type with 5 full threads.

2. Fittings and Boxes

a. Provide fittings and boxes with neoprene gaskets and non-magnetic stainless steel screws.

b. Attach covers by means of holes tapped into the body of the fitting.

c. Covers for fittings attached by means of clips or clamps will not be accepted.

3. Provide boxes larger than standard cast or malleable types manufactured of Type 304 or Type 316 stainless steel, NEMA 4X.

4. Terminations

a. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, Appleton, or equal.

b. In other than outdoor areas, provide sealed locknuts and bushings.

B. Cast Aluminum Fittings and Boxes

1. Provide cast aluminum boxes and fittings with less than 0.40 percent copper content, and use with aluminum conduit.

2. Manufacturer, or Equal

a. **O.Z. Gedney**

b. **Appleton**

c. **Crouse-Hinds**

C. Malleable Iron Fittings and Boxes

1. For use with galvanized steel conduit, provide fittings and boxes constructed of malleable iron or gray-iron alloy with zinc plating.

2. Manufacturer, or Equal

a. **O.Z. Gedney**

b. **Crouse-Hinds**

c. **Appleton**

D. PVC Fittings and Boxes

1. For use with rigid non-metallic conduit, provide fittings manufactured of solvent-welded PVC.

2. Provide boxes manufactured of PVC or fiberglass reinforced polyester (FRP).

3. Manufacturer, or Equal

    a. **Carlon**

    b. **Crouse-Hinds**

    c. **Hoffman**

4. Provide welding solvent as required for the installation of non-metallic conduit and fittings.

E. Stainless Steel Boxes

1. Provide stainless steel boxes with PVC-coated RGS conduit and where indicated.

2. Provide NEMA 4X stainless steel boxes, constructed of Type 304 stainless steel.

3. Provide stainless steel of a minimum of 14-gauge thickness, with a brushed finish.

4. Door Hinges

    a. Provide doors with full-length stainless steel piano hinges.

    b. Non-hinged boxes will not be accepted.

5. Manufacturer, or Equal

    a. **Hoffman**

    b. **Rohn**

    c. **Hammond**

F. Sheet Steel Boxes

1. Sheet steel boxes shall be galvanized steel outlet and switch boxes.

2. Manufacturer, or Equal

    a. **Raco**

    b. **Steel City**

    c. **Appleton Electric**

2.4 WIREWAY

A. General

1. Provide wireway of the lay-in type and NEMA-rated for the area in which it is to be installed in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

2. Separate power, control, signal and communications cables by grounded metallic dividers in wireways or run in separate wireways.

B. Fittings and Covers

1. Provide fittings and sections with non-magnetic stainless steel screws.

2. Attach covers by hinges and clamps to the bodies.

3. Covers attached by means of clips or screws will not be accepted.

4. Provide covers and bodies constructed of aluminum or minimum 14-gauge steel.

C. Grounding

1. Ground the steel and aluminum wireway bodies.

2. Provide steel dividers with steel wireways or aluminum dividers with aluminum wireways, and ground by means of an individual grounding conductor.

3. Non-metallic dividers will not be accepted.

D. Terminations

1. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Run wiring in raceway unless indicated otherwise.

B. Install raceways between equipment as indicated.

C. Provide raceway systems that are electrically and mechanically complete before conductors are installed.

D. Bends and Offsets

1. Provide bends and offsets that are smooth and symmetrical, and accomplished with tools designed for this purpose.

2. Provide factory elbows wherever possible.

E. Combined Raceways

1. Raceways other than those containing power conductors may be combined in strict accordance with the NEC and with prior written permission from the ENGINEER.

2. In general, combine only raceways containing the same type (control, signal, and the like) and voltage of conductors/cables, or dedicated conduits from one source to one device/equipment, in accordance with the NEC.

3. Permission from the ENGINEER shall not relieve the CONTRACTOR of responsibility to meet national, state and local requirements.

4. Do not combine wiring for redundant systems into single raceways.

F. Routing

1. Where raceway routings are indicated, follow those routings to the extent possible.

2. Where raceways are indicated but routing is not indicated, such as home runs or on conduit developments and schedules, raceway routing shall be the CONTRACTOR's choice and provided in strict accordance with the NEC as well as customary installation practice.

3. Provide the raceway encased, exposed, concealed, or under-floor as indicated, except conceal conduit in finished areas unless specifically indicated otherwise.

4. Adjust routings in order to avoid obstructions.

G. Coordination

1. Coordinate between trades prior to installing the raceways.

2. The lack of such coordination shall not be justification for extra compensation, and any costs for removal and re-installation to resolve conflicts shall be part of the Contract Price.

H. Support rod attachment for ceiling-hung trapeze installations shall meet the seismic requirements in the area where the Project is located.

I. Support wireways in accordance with the manufacturer's recommendations for the seismic requirements indicated in Section 26 00 00 – Electrical Work, General.

J. Install exposed raceways parallel or perpendicular to structural beams.

K. Expansion Fittings

1. Install expansion fittings with external bonding jumpers wherever exposed raceways cross building expansion joints.

2. Install expansion/deflection fittings where conduit movement is expected in more than one dimension, and where conduits transition out of structures in locations where differential settlement may occur.

3. Encased Expansion Fittings

    a. Install encased expansion fittings wherever encased conduits cross building expansion joints.

    b. Deflection type fittings shall not be required for encased conduits crossing an expansion joint within a single structure.

4. Provide expansion and expansion/deflection fittings constructed of the same material as the raceway to which they are installed.

L. Install expansion fittings with bonding jumpers wherever raceways cross building expansion joints.

M. Install exposed raceways at least 1/2 inch from walls or ceilings except that at locations above finished grade where damp conditions do not prevail, install exposed raceways at least 1/4 inch from the face of walls or ceilings by the use of clamp backs or struts.

N. Wherever contact with concrete or dissimilar metals can produce galvanic corrosion of equipment, provide a means of suitable insulation in order to prevent such corrosion.

3.2 CONDUIT

A. Provide exposed conduit manufactured of rigid aluminum, except as follows and unless indicated otherwise:

1. For conduit containing only grounding system bonding conductors, provide Schedule 80 PVC conduit.

B. Conduit encased in concrete shall be Schedule 40 PVC.

C. Concrete Encasement

1. Where PVC or RGS conduit is stubbed up from a concrete encasement, provide a PVC-coated RGS elbow.

2. The conduit shall emerge from the concrete in a direction perpendicular to the surface whenever possible.

3. Do not encase conduit in the bottom floor slab below grade.

D. Size

1. Provide exposed conduit of 3/4-inch minimum trade size.

2. Provide encased conduit of one-inch minimum trade size.

E. Install supports at distances required by the NEC.

F. Concrete cover for conduit and fittings shall not be less than 1-1/2 inches for concrete exposed to earth or weather, or less than 3/4 inch for concrete not exposed to weather or in contact with the ground.

G. Penetrations

1. Provide conduit passing through walls or floors with plastic sleeves.

2. Perform core drilling in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

3. Conduits passing through a slab, wall, or beam shall not significantly impair the strength of the construction.

H. Conduits embedded within a slab, wall, or beam (other than those merely passing through) shall meet the following requirements:

1. Conduits with their fittings embedded within a column shall not displace greater than 4 percent of the gross area of cross section;

2. Conduits shall not be larger in outside dimension than 1/3 the overall thickness of the slab, wall, or beam in which it is embedded; and,

3. Conduits shall not be spaced closer than 3 outside diameters on centers.

I. Place the conduit such that cutting, bending, or displacing reinforcement from its proper location will not be required.

J. Coat threads with a conductive lubricant before assembly.

K. Joints

1. Provide joints that are tight, thoroughly grounded, secure, and free of obstructions in the pipe.

2. Adequately ream the conduit in order to prevent damage to the wires and cables inside.

3. Use strap-wrenches and vises to install the conduit, in order to prevent wrench marks on the conduit.

4. Replace conduit with wrench marks.

5. Where installed in chemical or fuel containment areas, the conduit shall not have joints or fittings located below the top of the containment area to prevent entry of chemicals or fuel into the conduit system.

L. Slope

1. Wherever possible, slope the conduit runs to drain at one or both ends of the run.

2. Wherever conduit enters a substructure below grade, slope the conduit in order to drain water away from the structure.

3. Take extreme care in order to avoid pockets or depressions in the conduit.

M. Where conduits from duct banks enter building walls below grade, transition to PVC-coated RGS at least 12" outside the wall. Installation of PVC-coated rigid steel conduit though a core-drilled hole in an exterior wall below-grade shall utilize a sealing device as manufactured by **Link Seal**, or equal.

N. Connections

1. Make connections to lay-in-type grid lighting fixtures by using flexible metal conduit not exceeding 4 feet in length.

2. Make connections to motors and other equipment subject to vibration by using liquid-tight flexible conduit not exceeding 3 feet in length.

3. Provide equipment subject to vibration that is normally provided with wiring leads with a cast junction box for the make-up of connections.

O. Provide conduit seal fittings in hazardous classified locations, in strict accordance with the NEC.

P. Provide conduit, fittings, and boxes required in hazardous classified areas that are suitably rated for the area, and provide in strict accordance with NEC requirements.

Q. Duct sealant shall be foam duct sealant such as **Polywater FST or approved equal.** Provide duct sealant at the following locations:

1. Where required by NEC Article 300.7.

2. In areas where chlorine gas or fumes from sodium hypochlorite exist to prevent passage of gas through the raceway system.

R. Empty Conduits

1. Tag empty conduits at both ends to indicate the final destination.

2. Where it is not possible to tag the conduit, identify the destination by means of a durable marking on an adjacent surface.

3. Install a pull-cord in each empty conduit in floors, panels, manholes, equipment, and the like.

4. Install a removable plug on empty conduits that terminate below grade, in vaults, manholes, handholes, and junction or pullboxes.

S. Identification of Conduits

1. Identify conduits at ends and at pulling points.

2. Identification shall be the unique conduit number assigned in the Contract Documents.

3. Other than 120 VAC panelboard circuits, if a conduit has not been assigned a unique number in the Contract Documents, assign a unique number following the numbering scheme used in the Contract Documents.

4. Assign a unique number to 120 VAC panelboard circuits, similar to the cable numbering scheme used in the Contract Documents.

5. Provide conduit identification by a stamped or engraved non-corroding metal tag attached to the conduit bushing.

6. Provide an engraved phenolic nameplate in accordance with the requirements of Section 26 00 00 – Electrical Work, General, or a computer printed self-adhesive label attached to the equipment or enclosure inside which the conduit terminates.

7. Markings with a pen or paint will not be accepted.

T. Identification of Pullboxes and Junction Boxes

1. Identify pullboxes and junction boxes.

2. Identification shall be the unique conduit number assigned in the Contract Documents, or if not assigned a unique number the CONTRACTOR shall assign one following the numbering scheme used in the Contract Documents.

3. Provide box identification by a stamped or engraved non-corroding metal tag or an engraved phenolic nameplate, in accordance with the requirements of Section 26 00 00 – Electrical Work, General, and attached to the box or enclosure.

4. Markings with a pen or paint will not be accepted.

U. Provide conduit for data cables in accordance with the equipment manufacturer's recommendations, especially regarding separation from low- and medium-voltage power raceways.

END OF SECTION

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SECTION 26 05 36
WIRING DEVICES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide wiring devices, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 – Electrical Work, General apply to this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

B. Shop Drawings

1. Submit complete catalog cuts of switches, receptacles, enclosures, covers and appurtenances, marked to clearly identify the proposed materials.

2. Submit documentation showing that the proposed materials comply with the requirements of NEC and U.L.

3. Submit documentation of the manufacturer's qualifications.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Devices shall carry the U.L. label, and shall be designed for use with stranded copper conductors.

B. Color

1. General purpose duplex receptacles and toggle switch handles shall be Brown everywhere except unless otherwise indicated.

2. Special purpose receptacles shall have a body color as indicated.

C. Receptacles and switches shall be of specification grade and shall conform to NEMA WD-1, Federal Specifications W-C-596E and W-S-896E, respectively.

2.2 LIGHTING SWITCHES

A. Toggle switches shall be AC only type switch.

1. 20A, 120/277V, Single, Double, 3-Way and 4-Way, Respectively

a. **Leviton**: 1221-2, 1222-2, 1223-2, 1224-2
b. **Hubbell:** HBL1221, HBL1222, HBL1223, HBL1224
c. **Pass and Seymour:** PS20AC1, PS20AC2, PS20AC3, PS20AC4
d. **Or Equal**

2.3 GENERAL PURPOSE RECEPTACLES

A. Duplex receptacles shall be of the polarized 3-wire type for use with a 3-wire cord with grounded lead, and one designated stud shall be permanently grounded to the conduit system in accordance with NEC article 406.4.

B. Dry Areas

1. NEMA Configuration #5-20R: duplex receptacle rated 125V, 20A

a. **Leviton:** #5362
b. **Hubbell:** #HBL5362
c. **Pass and Seymour:** #5362A
d. **Or Equal**

2. NEMA Configuration #5-30R single receptacle rated 125V, 30A

a. **Leviton:** #5371
b. **Hubbell:** #HBL9308
c. **Or Equal**

C. Damp/Wet Areas

1. Receptacles for damp/wet locations shall be weather-resistant with extra duty, in-use listed covers in accordance with NEC Article 406.8.

D. GFCIs

1. Ground-fault circuit-interrupting receptacles (GFCIs) shall be installed at the indicated locations and as required by the NEC.

2. GFCIs shall be duplex receptacles, of specification grade, and tripping at 5 mA.

3. GFCI ratings shall be 125V, 20 amperes, NEMA WD-1, Configuration 5-20R, and capable of interrupting 5,000 amperes without damage.

4. GFCIs shall be weather resistant-listed in accordance with NEC Article 406.8.

5. Feed-through-type GFCIs serving standard receptacles will not be permitted.

a. Leviton: G5362-WT
b. **Hubbel:** GFR5362SG
c. **Or Equal**

2.4 ENCLOSURES AND COVERS

A. Surface-mounted switches and receptacles shall be housed in FS or FD-type weatherproof conduit fittings.

B. Switch and receptacle covers on surface-mounted boxes shall be constructed of die-cast copper-free aluminum.

1. **Appleton**: FSK
2. **Crouse-Hinds**: DS185 and WLRD-1
3. **Hubbell Killark**: FZ and FC
4. **Or Equal**

C. In finished areas, switch and receptacle covers shall be constructed of stainless steel.

D. Wet Locations

1. Receptacles in wet locations shall be provided with a hinged non-metallic Clear cover/enclosure marked "Suitable for Wet Locations when in use" and "UL Listed."

2. Provide a gasket between the enclosure and the mounting surface, and between the hinged cover and mounting plate/base.

a. **Appleton**: WCIU
b. **Crouse-Hinds**: TP74
c. **Hubbell TayMac:** Extra Duty
d. Or Equal

2.5 NAMEPLATES

A. Provide nameplates or equivalent markings on the switch enclosures to indicate the ON and OFF positions of each switch.

B. ON and OFF for 3-way or 4-way switches will not be accepted.

C. Provide receptacles for special purposes with nameplates indicating their use.

D. Nameplates shall meet the requirements of Section 26 00 00 – Electrical Work, General.

PART 3 -- EXECUTION

3.1 GENERAL

A. Perform WORK in accordance with the requirements of the NEC.

3.2 CONNECTION

A. Rigidly attach wiring devices in accordance with the NEC and as indicated, avoiding interference with other equipment.

B. Securely fasten nameplates using screws, bolts, or rivets centered under or on the device, unless otherwise indicated.

C. Nameplates shall meet the requirements of Section 26 00 00 – Electrical Work, General, and shall consist of a red plate with white letters a minimum of 1/4 inch tall.

3.3 GROUNDING

A. Devices, including switches and receptacles, shall be grounded in accordance with NEC, Article 250, and Section 26 05 26 – Grounding.

B. Switches and associated metal plates shall be grounded through the switch mounting yoke, outlet box, and raceway system.

C. Flush Receptacles

1. Flush receptacles and their metal plates shall be grounded through positive ground connections to the outlet box and grounding system.

2. Maintain the ground to each receptacle by a spring-loaded grounding contact to the mounting screw, or by a grounding jumper, each making a positive connection to the outlet box and grounding system at all times.

D. Receptacles served from an uninterruptible power supply shall be provided with an isolated grounding conductor from the serving power panelboard.

3.4 FIELD TESTING

A. Provide checkout, field, and functional testing of wiring devices in accordance with Section 26 00 00 – Electrical Work, General.

B. Test each receptacle for polarity and ground integrity, using a standard receptacle tester.

END OF SECTION

SECTION 26 05 43
UNDERGROUND RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide underground raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. Manholes, pullboxes, and fittings that are dedicated to the underground raceway system shall comply with the requirements of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals, and Section 26 00 00 – Electrical Work, General.

B. Shop Drawings

1. Submit complete catalog cuts of all raceways, fittings, pullboxes, and manholes, marked where applicable in order to show proposed materials and finishes.

C. As-Built Drawings

1. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

2. Show routings, burial depths, manhole and handhole locations and sizes, and where applicable, connections to drainage systems.

3. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

PART 2 -- PRODUCTS

2.1 MANHOLES AND PULLBOXES

A. Frames and Covers

1. Provide traffic-type covers with an H-20 loading, except as otherwise indicated.

2. Identify manhole and pullbox covers as "ELECTRIC" by providing raised letters cast into the covers.

3. Provide frost-proof and water-tight grey iron frames and covers with solid lids and inner lids, and with 28-inch clear openings.

4. Bolt the covers and lids to cast-in-place steel frames using corrosion-resistant hardware.

5. Factory-prime the frames.

6. Provide covers constructed of cast-iron, and provide pick holes.

7. Provide frames with a 1/2-inch drilled and tapped hole and lug in order to accommodate a No. 4/0 AWG bare stranded copper conductor connected to a ground rod and the ground conductor of power cables passing through the manhole.

8. Manhole frames and covers shall be **Neenah Foundry No. NF-1755GT18** or equal.

B. Equip manholes and pullboxes with pulling-in irons, opposite and below each ductway entrance.

C. Provide manholes and pullboxes with closed bottoms; open-bottom manholes and pullboxes will not be accepted.

D. Provide PVC ductbank conduits with end bells.

E. Brackets

1. Provide non-metallic, non-conductive brackets and stanchions in manholes as required for racking wiring through the manholes. Attach to manhole walls using stainless steel anchors and hardware.

2. Brackets and stanchions: **Underground Devices, Inc.,** or equal.

F. Precast Manholes and Pullboxes Manufacturer, or Equal

1. **Jensen Precast**

2. **Mack**

3. **Quikset**

4. **U.S. Precast**

2.2 DUCTBANKS

A. Provide underground ducts constructed of Schedule 40 PVC.

B. Encase ducts in red-dyed concrete with steel reinforcing bars.

C. Provide concrete with a 3,000-psi compressive strength conforming to the requirements of Section [[[03 31 50]]] – Cast-in-Place Concrete.

D. Colorant

1. The concrete shall be dyed red throughout the ducts; surface treatment will not be accepted.

2. Provide colorant consisting of an integral red-oxide coloring pigment in the proportion of 8 pounds per cubic yard of concrete.

3. The costs, if any, of cleaning coloring pigment from the concrete delivery equipment and other related cleanings shall be considered as part of the WORK.

E. Ductbanks

1. Ductbanks shall contain a No. 4/0 bare stranded copper ground wire.

2. The ground wire shall be continuous through the ductbank and terminate at power distribution equipment and the grounding grid.

F. Identification Tape

1. Provide continuous lengths of underground warning tapes located 12 inches above and parallel to the ductbanks.

2. Provide tape consisting of 6-inch wide polyethylene film, imprinted with "CAUTION - ELECTRIC UTILITIES BELOW."

3. Tape Manufacturer, or Equal: **Brady**

PART 3 -- EXECUTION

3.1 GENERAL

A. Install underground raceways between manholes and pullboxes as indicated.

B. Raceway systems shall be electrically and mechanically complete before conductors are installed.

C. Provide bends and offsets that are smooth and symmetrical, and fabricated with tools designed for this purpose.

D. Use factory elbows wherever possible.

E. To the extent possible, follow the raceway routings as indicated on the Drawings.

F. Adjust the indicated routings as necessary in order to avoid obstructions.

G. Coordination with Other Trades

1. Coordinate with other trades prior to installation of raceways.

2. The lack of coordination shall not be justification for extra compensation.

3. Perform removal and re-installation to resolve conflicts as part of the WORK.

3.2 DUCTBANKS

A. Install ductbanks in accordance with the following criteria:

1. Assemble the duct using high-impact, non-metallic spacers and saddles in order to provide conduits with vertical and horizontal separation.

2. Set the plastic spacers every 5 feet.

3. Anchor the duct array every 5 feet in order to prevent movement during the placement of concrete.

4. Lay the duct on a grade line of at least 3 inches per 100 feet, sloping towards pullboxes or manholes.

5. Install the duct and adjust the pullbox and manhole depths such that the top of the concrete envelope is a minimum of 18 inches below grade and a minimum of 24 inches below roadways.

6. Accomplish changes in direction of the duct envelope by more than 10 degrees horizontally or vertically by using bends with a minimum radius 24 times the duct diameter.

7. Stagger duct couplings a minimum of 6 inches.

8. Provide select backfill or sand for the bottom of the trench.

9. Cleaning

a. Clean each bore of the completed ductbank by drawing through it a standard flexible mandrel, one foot long and 1/4 inch smaller than the nominal size of the duct.

b. After passing the mandrel, draw through a wire brush and swab.

10. For spare raceways that are not indicated to contain conductors, provide a 1/8-inch polypropylene pull cord installed throughout the entire length of the raceway.

B. Grout duct entrances smooth, and terminate ducts with flush end bells.

C. Assemble sections of pre-fabricated manholes and pullboxes using waterproof mastic, and set on a 12-inch bed of gravel as recommended by the manufacturer or as required by field conditions.

D. Provide watertight ductbank penetrations through walls of manholes, pullboxes, and building walls below grade.

E. Terminate concrete-encased ductbanks at building foundations.

F. Where ducts enter buildings, provide duct sealant in every duct at the building-end of the duct run to prevent water or condensation entry from the duct bank into the building. Duct sealant shall be **Polywater FST, Polywater FST-Mini,** or equal.

G. When duct enters the building on a concrete slab on grade, do not encase the duct but transition to rigid steel PVC-coated conduits on stub-ups.

H. Sealing

1. Where an underground conduit enters a structure through a concrete roof or a membrane-waterproofed wall or floor, provide a **Link-Seal** or equal sealing device.

2. Use the sealing device with rigid steel conduit.

3. Transition from PVC to rigid steel conduit prior to building entry.

END OF SECTION

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SECTION 26 05 73
PROTECTIVE DEVICE STUDIES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall perform the indicated short circuit and protective device studies for the electrical power system in accordance with the Contract Documents.

B. The WORK of this Section shall include protection studies for motors with solid state overload and overcurrent protection devices.

C. It is the responsibility of the CONTRACTOR to obtain the information required from the electric utility and appropriate vendors.

1.2 QUALIFICATIONS

A. Short circuit studies, protective device evaluation studies, arc-flash hazard analysis studies, and protective device coordination studies shall be performed by a manufacturer who has been regularly engaged in short circuit and protective device coordination services for a period of at least 15 years.

B. The indicated studies shall be signed by the professional electrical engineer, registered in the State of Utah, responsible for the studies.

C. The studies shall utilize computer programs with proven reliability and accuracy for performing 3-phase fault-duty calculations.

1.3 CONTRACTOR SUBMITTALS

A. The indicated studies shall be submitted and approved by the ENGINEER prior to final approval of the distribution equipment Shop Drawings and release of equipment for manufacture.

B. An initial short circuit study shall be submitted and reviewed before the ENGINEER will approve the Shop Drawings for medium-voltage switchgear, transformers, or 480-volt distribution equipment.

C. An initial protective device coordination study shall be submitted with 90 days after the approval of the initial short circuit study.

D. The short circuit, arc-flash hazard analysis, and protective device coordination studies shall be updated prior to Project Substantial Completion; utilize characteristics of as-installed equipment and materials.

E. The adequacy of the equipment "withstand" and interruption ratings shall be approved by the ENGINEER.

1.4 MANUFACTURERS' SERVICES

A. The low-voltage switchboard manufacturer shall furnish the services of a qualified field engineer and necessary tools and equipment in order to test, calibrate, and adjust the protective relays and circuit breaker trip devices as recommended in the power system coordination study.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 GENERAL

A. The studies shall include development of single-line and impedance diagrams of the power system.

B. The diagrams shall identify components considered in the study and the ratings of power devices, including transformers, circuit breakers, relays, fuses, busses, and cables.

C. The resistances and reactances of cables shall be identified in the impedance diagram.

D. The studies shall contain written data from the electric utility company regarding maximum available short circuit current, voltage, and X/R ratio of the utility power system.

E. The studies shall include every protective device and feeder included within the WORK.

F. The first upstream overcurrent device outside the WORK shall be used as a fixed reference.

G. The studies shall include all portions of the electrical distribution system for normal and standby power sources down to and including the 480-volt distribution system.

3.2 SHORT CIRCUIT STUDY

A. The short circuit study shall be performed with the aid of a digital computer program, and shall be in accordance with the following Standards:

ANSI/IEEE 141	Recommended Practice for Electrical Power Distribution for Industrial Plants
ANSI/IEEE 242	Recommended Practice for Protection, and Coordination of Industrial, and Commercial Power Systems
ANSI/IEEE C 37.010	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI/IEEE C 37.13	Low-Voltage AC Power Circuit Breakers Used in Enclosures

3.3 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device evaluation study shall be performed in order to determine the adequacy of circuit breakers, molded case switches, and fuses.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the attention of the ENGINEER.

C. Do not utilize series-rated circuit breakers to meet short circuit requirements for this project.

D. Devices shall be fully rated to withstand available fault currents.

3.4 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device coordination study shall be performed in order to develop the necessary calculations to select power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage breaker trip characteristics and settings.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the ENGINEER's attention.

3.5 TIME/CURRENT COORDINATION CURVES

A. As a minimum, the time/current coordination curves for the power distribution system shall include the following items plotted on 5-cycle log-log graph paper:

1. time/current curves for each protective relay, circuit breaker, or fuse demonstrating graphically that the settings will provide protection and selectivity within industry standards

2. Each curve shall be identified, and tap and time dial settings shall be specified.

3. Provide individual curves for each feeder unless identical to others.

4. Selectivity

a. Time/current curves for each device shall be positioned to provide the maximum selectivity to minimize system disturbances during fault clearing.

b. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.

c. Recommendations shall be included for alternate methods that would improve selectivity.

5. time/current curves and points for cable and equipment damage.

6. circuit interrupting device operating and interrupting times

7. Indicate maximum fault values on the graph.

8. sketch of bus and breaker arrangement

9. magnetizing inrush points of transformers

10. thermal limits of dry-type and liquid-insulated transformers (ANSI damage curve)

11. Every restriction of the ANSI and National Electrical Code shall be followed, and proper coordination intervals and separation of characteristics curves shall be maintained.

3.6 ARC FLASH STUDY

A. An arc flash study shall be performed with the aid of a digital computer program in order to determine the "Arc Flash Protection Boundary" and "Personal Protective Equipment" (PPE) levels for applicable electrical distribution equipment, stand-alone disconnects, starters, and VFDs in the power distribution system.

B. The arc flash study shall be performed in conjunction with short circuit calculations and protective device coordination.

C. The arc flash study shall be in accordance with the latest version of the following Standards:

1. NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces

2. IEEE 1584 IEEE guide for performing Arc Flash Hazard Calculations

3. OSHA (29 CFR PART 1910) Occupational Safety and Health Standards for General Industry

4. ANSI Z535.4 Product Safety Signs and Labels

D. The recommended values for the "Arc Flash Protection Boundary" and PPE levels, based on the arc flash study results, shall be tabulated in the study.

E. Labeling

1. The digital computer program shall provide the "Arc Flash Protection Boundary" and PPE values in a format that can be directly printed on to labels.

2. The CONTRACTOR shall provide these labels in accordance with Section 26 00 00 – Electrical Work, General.

3.7 FINAL SUMMARY REPORT

A. Summarize the results of the indicated power system studies in a final report.

B. The report shall include the following items:

1. single-line diagram

2. impedance diagram

3. tabulation of all protective devices identified on the single line diagram

4. time/current coordination curves

5. specific recommendations, if any

6. test instrumentation, condition, and connections, as applicable, for each study

7. computerized fault current calculations

8. any suggested changes to the protection scheme or equipment selection that will result in improved system reliability and safety

9. recommendations to minimize the arc flash energy

C. The report shall include information concerning the computer program used for the study, as well as a general discussion of the procedure, items, and data considered in the preparation of the study.

D. Submit 3 bound copies of the report to the ENGINEER.

3.8 PROTECTIVE DEVICE TESTING, CALIBRATION, AND ADJUSTMENT

A. Test, calibrate, and adjust the protective relays and circuit breaker trip devices in accordance with the recommendations in the power system coordination study.

B. Calibrate the MCPs as in accordance with the recommendations in the power system study.

C. Adjustments shall be made prior to energizing any electrical equipment.

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SECTION 26 12 16
PANELBOARDS AND GENERAL PURPOSE DRY TYPE TRANSFORMERS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide panelboards and general purpose dry-type transformers, complete and operable, in accordance with the Contract Documents.

B. Single Manufacturer: Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals and Section 26 00 00 - Electrical Work, General.

B. Shop Drawings

1. Transformers

a. Dimension drawings

b. Technical certification sheets

c. Drawing of conduit entry/exit locations

d. Transformer ratings, including:

1) Voltage

2) Continuous current

3) Basic impulse level for equipment over 600 volts

4) KVA

e. Descriptive bulletins

f. Product sheets

2. Panelboards

a. Breaker layout drawings with dimensions and nameplate designations

b. Component list

c. Drawings of conduit entry/exit locations

d. Assembly ratings including:

1) Short circuit rating

2) Voltage

3) Continuous current

e. Cable terminal sizes

f. Descriptive bulletins

g. Product sheets

h. Installation information

i. Seismic certification and equipment anchorage details

PART 2 -- PRODUCTS

2.1 GENERAL

A. Transformers

1. The transformers shall be dry-type, designed, manufactured, and tested in accordance with the latest applicable standards of ANSI and NEMA.

2. Transformers shall be UL-listed and bear the UL label.

B. Panelboards

1. Panelboards shall be dead front factory assembled. Panelboards shall comply with NEMA PB-1-Panelboards, as well as the provisions of UL 50 - Safety Enclosures for Electrical Equipment and UL 67 - Safety Panelboards. Panelboards used for service equipment shall be UL labeled for such use. Lighting panelboards shall be rated for 120/208 volt, 3 phase operation or 120/240 volt for single phase operation as indicated. Power panelboards shall be rated for 480 volts, 3 phase, 3 wire operation, unless indicated otherwise.

2. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers.

2.2 TRANSFORMERS

A. Energy Efficiency: Standard dry-type transformers shall meet the energy efficiency requirements of the Department of Energy Code of Federal Regulations (10 CFR PART 431), DOE 2016 Efficiency Levels.

B. Ratings

1. KVA and voltage ratings shall be as indicated.

2. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96 - Guide for Loading Dry Type Distribution and Power Transformers

3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

Up to 9 kVA	40 dB
10 to 50 kVA	45 dB
51 to 150 kVA	50 dB

C. Construction

1. Insulation Systems

a. Transformers shall be insulated as follows:

1) 2 kVA and smaller: 150 deg C insulation system based upon 80 deg C rise.

2) 3 to 15 kVA: 185 deg C insulation system based upon 115 deg C rise.

3) 15 kVA and larger: 220 deg C insulation system based upon 150 deg C rise.

b. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 deg C maximum ambient.

c. Insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM D 635 - Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

2. Transformer windings shall be copper.

3. Transformers shall have four 2-1/2 percent taps, 2 above and 2 below 480 volts.

4. Transformer shall include vibration dampeners between the core and the enclosure to minimize and isolate sound transmission.

D. Manufacturers: **General Electric, Eaton, Schneider Electric/Square D Company, or equal**.

2.3 PANELBOARDS

A. Ratings

1. Panelboards rated 240 VAC or less shall have short circuit ratings not less than 10,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.

2. Panelboards rated 480 VAC shall have short circuit ratings not less than 65,000 amperes RMS symmetrical or as indicated by the Protective Device Study, whichever is greater.

3. Panelboards shall be labeled with a UL short circuit rating. Series ratings are not acceptable.

B. Construction

1. Lighting and power distribution panels shall have tin-plated copper bus bars.

2. Breakers shall be one, 2, or 3 pole as indicated, with ampere trip ratings as required by the equipment. Breakers shall be quick-make and quick-break, inverse time trip characteristics, to trip free on overload or short circuit, and to indicate trip condition by the handle position.

3. The panels shall have hinged doors with combination catch and latch. The front panels shall be so arranged that when the plates are removed, the gutters, terminals and wiring will be exposed and accessible. The doors shall have inner doors within the plates to have only the breaker operating mechanism exposed when they are opened. Live conductors and terminals shall be concealed behind the plates.

4. Panelboards shall be rated for the intended voltage.

5. Circuit breakers shall be interchangeable and capable of being operated in any position as well as being removable from the front of the panelboard without disturbing adjacent units. No plug-in circuit breakers will be acceptable.

6. Lighting and power distribution panels which are not part of a motor control center shall be constructed in accordance with Section 26 00 00 – Electrical Work, General. Panels shall have the necessary barriers, supports, and liberal wiring gutters. Trim screws shall be stainless steel. Panelboard parts of metal other than copper, aluminum, or stainless steel shall be cadmium plated.

7. Panelboards shall be UL listed except for special enclosures which are not available with UL listing.

8. Panelboards shall be suitable for use as service entrance where indicated.

C. Manufacturers: **General Electric, Eaton, Schneider Electric/Square D Company, or equal**

D. Surge Protection Devices (SPD)

1. Provide integral SPDs. SPDs shall conform to Section 26 43 00 – Surge Protection Devices.

2. SPD units shall be rated for the voltage and phase service of the panel at 120 kA per phase.

PART 3 -- EXECUTION

3.1 GENERAL

A. WORK of this Section shall be installed as indicated in Section 26 00 00 – Electrical Work, General.

END OF SECTION

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SECTION 26 24 13
480V SWITCHBOARD

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide the 480V switchboard, complete and operable as indicated and in accordance with the Contract Documents.

B. The requirements of Section 26 00 00 – Electrical Work, General apply to the WORK of this Section.

C. UL Label

1. The switchboard assembly shall bear a UL label.

2. Furnish certified copies of design test reports demonstrating compliance with UL standards.

D. Single Manufacturer

1. The low voltage switchgear shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Codes

1. The indicated WORK shall conform to or exceed the applicable requirements of the National Electrical Code (NEC), provided that where a local code or ordinance is in conflict with the NEC, the provisions of the local code or ordinance shall take precedence.

B. Commercial Standards

ANSI/NFPA 70	National Electrical Code – 2017
UL 891	Dead-Front Switchboard
NEMA PB2	Dead-Front Distribution Switchboard
NEMA PB2.1	Proper Handling, Installation, Operation and Maintenance of Dead-front Switchboards Rated 600 volts or less.

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall conform to the requirements of Section 26 00 00 – Electrical Work, General, and Section 01 33 00 – Submittals.

B. In addition, submit the following:

1. A complete list of special tools as may be required for the operation and maintenance of the unit.

2. Engineering data, including voltage, current, and short-circuit ratings.

3. Certified outline drawings complete with dimensions, available space for conduits, cable terminations, bus terminations, weights, and cable supports.

4. A complete one-line diagram showing protective devices and terminal numbers.

5. Interconnection diagrams.

6. Design certification of the anchoring systems for seismic requirements in conformance with the requirements of Section 26 00 00 – Electrical Work, General, for the indicated equipment.

7. Spare parts data, listing source and prices of recommended replacement parts and supplies.

8. Recommended maintenance procedures and intervals.

9. A certified factory design test report.

10. A material list and catalog data.

1.4 QUALITY ASSURANCE

A. General

1. Materials shall be tested and inspected in accordance with Section 26 00 00 – Electrical Work, General, and the requirements indicated in this Section.

B. Storage and Warranty

1. Switchboard shall be stored in a clean, dry space.

2. Factory wrapping shall be maintained or a heavy plastic cover shall be provided in order to protect units from dirt, water, construction debris, and traffic.

3. The storage space shall be heated.

4. Equipment furnished under this section shall be guaranteed against defective parts and workmanship under the terms of the manufacturers and suppliers standard warranty. In no event shall it be for a period of less than three (3) years after the date of acceptance of the system and shall include labor, materials and travel costs for necessary repairs at the job site.

C. Factory Tests

1. Submit a certification of design tests previously conducted on a circuit breaker and switchboard assembly of each rating similar to that indicated.

2. The design testing program shall conform to the requirements of ANSI/IEEE C37.20.1, and shall include the following tests:

   a. dielectric

   b. continuous current

   c. withstand

   d. endurance

3. After assembly, the complete switchboard shall be tested for operation under simulated service conditions in order to assure the accuracy of the wiring and the functionality of the equipment.

D. Environmental Conditions

1. The 480V switchboard shall be designed for continuous duty service in the environmental conditions indicated in Section 26 00 00 – Electrical Work, General.

PART 2 -- PRODUCTS

2.1 REQUIREMENTS

A. Switchboards shall be "fully-rated" for the available short circuit current of 65 KAIC. "Series-rated" equipment is not acceptable.

B. The switchboard shall be dead front construction, NEMA 1A gasketed enclosure, and consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.

C. All sections of the switchboard shall be rear aligned with depth as shown on the drawings. All protective devices shall be group mounted. Devices shall be front removable and load connections front accessible enabling the switchboard to be mounted against a wall.

D. The assembly shall be provided with adequate lifting means.

E. All exposed copper shall be tin-plated. Copper shall be tin-plated after all cutting, shearing, and drilling operations so that there is no exposed copper in the finished equipment.

F. Switchboards shall include Zone Selective Interlocking where indicated on the drawings.

2.2 BUS

A. All bus bars shall be tin-plated copper with silver plated joints. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65°C over a 40°C ambient (outside the enclosure).

B. Provide a half capacity neutral bus where a neutral bus is indicated on the drawings.

C. A tin-plated copper ground bus (minimum ¼ inch by 2 inches), shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.

D. All hardware used on conductors shall be high-tensile strength and zinc plated. All bus joints shall be provided with conical spring-type washers. Supports shall be high-impact, non-tracking insulating material.

2.3 WIRING/TERMINATIONS

A. Mechanical-type terminals shall be provided for all line and load terminations, suitable for copper cable rated for 75°C.

B. Lugs shall be provided within the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as required.

2.4 CIRCUIT BREAKERS

A. Product description: UL489, molded-case circuit breakers.

B. Circuit breakers with frame size 800A and 600A shall be provided with electronic trip units with adjustable current and time settings and zone selective interlock protection.

2.5 Surge Protection Devices

A. See specification 26 43 00 - Surge Protection Devices

2.6 Metering

A. Provide solid-state metering where indicated.

B. Include CTs and PTs of ratios as indicated or as recommended by the Switchboard manufacturer.

C. The CT leads shall terminate on shorting type terminal blocks, and the shorting bar shall be grounded to the switchboard ground bus.

D. Solid-state metering shall be **G.E. "PQM", Eaton "DP-4000," Square D "Power-Logic,"** or equal.

2.7 MANUFACTURER, or equal:

A. **Eaton**

B. **Square D/Schneider Electric**

C. **ABB**

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall install switchboard in accordance with the manufacturer's published instructions.

B. Conduit installation shall be coordinated with the manufacturer's as-fabricated drawings.

C. Conduit shall be installed in the section that contains the devices to which conductors are terminated.

3.2 INSTALLATION

A. Switchboard shall be installed on 3-1/2-inch concrete pads and in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

B. After leveling and shimming, the CONTRACTOR shall anchor switchboard to the concrete pads, and shall grout such that no space exists between the pad and support beams.

C. The CONTRACTOR shall:

1. Torque bus bar bolts to manufacturer's recommendations and tighten sheet metal and structure assembly bolts.

2. Touch up scratches after the equipment has been installed.

3. Verify that nameplates, and other identification is accurate.

4. Provide high-voltage switchboard matting in front of the switchboard, in accordance with the requirements of Section 26 00 00 – Electrical Work, General.

3.3 FIELD TESTS – (SEE ALSO SECTION 26 01 26 – ELECTRICAL TESTS)

A. Provide a visual and mechanical inspection after installation, as follows:

1. Inspect for physical damage, proper anchorage, and grounding.

2. Check tightness of bolted connections.

B. Electrical Tests

1. Insulation Tests

a. Measure the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute.

b. The test voltage and minimum acceptable resistance shall be in accordance with manufacturer's recommendations.

c. The test voltage and minimum acceptable resistance shall be in accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 26 29 23
VARIABLE FREQUENCY DRIVE UNITS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General

1. The CONTRACTOR shall provide variable frequency drive (VFD) units, complete and operable, as indicated in accordance with the Contract Documents.

2. It is the intent of this Section to require complete, reliable, and fully tested variable frequency drive systems suitable for attended or unattended operation.

B. The requirements of Section 26 00 00 – Electrical Work, General, apply to the WORK of this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.

2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

D. Coordination

1. Equipment provided under this Section shall operate the electric motor driver and the driven equipment as indicated under other equipment specification Sections.

2. The CONTRACTOR'S attention is specifically directed to the need for proper coordination of the WORK under this Section and the WORK under the equipment Section with the WORK under Section 26 29 00 – Electric Motors.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals, except that Shop Drawing information for the drives shall be submitted as part of the information for the driven equipment.

B. Shop Drawings: Include the following information:

1. Equipment Information

a. name of drive manufacturer

b. type and model

c. assembly drawing and nomenclature

d. maximum heat dissipation capacity in kW

2. conduit entrance provisions

3. circuit breaker type, frames, and settings

4. information related to relays, timers, pilot devices, control transformer VA, dV/dT devices, line reactors and fuse sizes, including catalog cuts

5. Ladder Diagram

   a. Submit the system schematic ladder diagram and interconnection diagrams.

   b. The schematic ladder diagram shall include remote devices.

   c. The ladder diagram shall incorporate the control logic on the corresponding elementary schematic as indicated.

   d. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the CONTRACTOR stamped "REJECTED."

6. factory test data certifying compliance of similar equipment from the same manufacturer with requirements of this Section

C. The Technical Manual shall include the following documentation:

1. manufacturer's 2-year warranty

2. harmonic analysis report

3. field test report

4. programming procedure and program settings

D. Spare Parts List

1. Submit information for parts required by this Section plus any other spare parts recommended by the controller manufacturer.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide a total of 7 variable frequency drives.

B. Equipment to be operated through variable frequency drives shall include the following:

Quantity	Equipment	HP	Constant or Variable	RPM	Bypass (Y/N)	Enclosure Type

			Torque (C/V)			
3	Secondary Reuse Pump	200	C	1800	N	12
1	Secondary Reuse Pump	50	C	1800	N	12
3	Effluent Return Pump	15	C	1800	N	12

2.2 EQUIPMENT

A. General

1. The power supply shall be an adjustable frequency inverter designed to convert incoming 3-phase, 480-volt, 60-Hertz power to a DC voltage and then to adjustable frequency AC by use of a 3-phase inverter.

2. Current-source inverters will not be accepted.

3. Inverters shall be sized to match the KVA and inrush characteristics of the motors actually provided.

4. The CONTRACTOR shall be responsible for matching the controller to the load (variable torque or constant torque) as well as the speed and current of the actual motor being controlled.

5. The CONTRACTOR shall provide "clean power" 18-pulse VFD's for VFDs that are operating motors greater than 50 HP.

B. Inverter

1. The inverter shall be of a voltage-source design, producing a pulse-width-modulated type output.

2. Six-step and current-source inverters will not be accepted.

3. Motors

a. Inverters shall be provided with 460-volt, 3-phase, 60-Hertz, squirrel-cage high-efficiency inverter duty induction motors.

b. Motors shall be capable of operating over the range of 50-100 percent of base speed without derating or requiring any motor modifications.

c. Motors enclosures shall be NEMA B, open drip-proof (1.15 SF) or TEFC (1.15 SF).

4. Inverters shall be capable of delivering the nameplate horsepower exclusive of service factor without the need for mandatory thermostats or feedback tachometers.

5. The VFD shall vary both the AC voltage and frequency simultaneously in order to operate the motor at required speeds.

C. The minimum VFD inverter efficiency shall be 95 percent at 100 percent speed and load, and 85 percent efficiency at 50 percent speed and load.

D. Power Outage

1. The VFD shall shut down in an orderly manner when a power outage occurs on one or more phases.

2. Upon restoration of power and a START signal, the motor shall restart and run at the speed corresponding to the current process input signal.

E. The VFD shall be provided with the following features:

1. inrush current adjustment between 50 and 110 percent of motor full load current (factory set at 100 percent)

2. overload capability at 110 percent for 60 seconds for variable torque loads and 150 percent for constant torque loads.

3. adjustable acceleration and deceleration

4. input signal of 4 - 20 mA from process

5. output speed signal of 4 - 20 mA; Signals other than 4 - 20 mA will not be accepted.

6. Upon loss of input signal, the VFD shall operate at a preset speed.

7. a minimum of 2 selectable frequency jump points in order to avoid critical resonance frequency of the driven system.

8. additional devices and functions as indicated

9. Ethernet TCP/IP I/O communications to transmit VFD data to/from a plant PLC-based control system

F. The VFD shall be provided with, as a minimum, the following protection features:

1. input line protection with metal oxide varistor (MOV) and RC network

2. protection against single phasing

3. instantaneous overcurrent protection

4. electronic overcurrent protection

5. ground fault protection

6. overtemperature protection for electronics

7. protection against internal faults

8. ability to start into rotating motor (forward or reverse rotation)

9. additional protection and control as indicated and as required by the motor and driven equipment

G. The VFD shall be designed and constructed to satisfactorily operate within the following service conditions.

1. Elevation

a. elevation to 3300 feet

b. For elevation greater than 3300 feet, the VFD shall be derated in accordance with the manufacturer's recommendation

2. Ambient Temperature: 0 to 40 degrees C

3. Humidity: 0 to 95 percent, non-condensing

4. AC Line-Voltage Variation: plus 10 percent to minus 10 percent

5. AC Line-Frequency Variation: plus and minus 2 Hertz

H. Electrical equipment provided in addition to the adjustable frequency inverter for each drive shall include:

1. 2-1/2-percent (minimum) line reactor integral to the drive enclosure.

2. Provide a dV/dT filter device at the motor or VFD output per the manufacturer’s recommendation. Submit documentation demonstrating where such devices are required, along with mounting and cabling requirements.

3. fused 480-to-120-volt control transformer to provide system control power for the logic and pilot lamps.

4. Provide an input circuit breaker.

5. Heaters

a. Provide overload heaters with auxiliary contacts in order to protect the motors in both VFD and bypass modes.

b. Refer to the Elementary Schematics indicated on the Drawings.

c. The heaters shall be sized for the motor actually being provided.

I. Inverter Signal Circuits

1. The inverter signal circuits shall be isolated from the power circuits and shall be designed to accept an isolated 4-20 mA signal in the automatic mode of operation.

2. The inverter shall follow the setting of a remote or local potentiometer control while in the manual mode.

3. Refer to the Elementary Schematic indicated on the Drawings for speed control and START/STOP methods.

4. Access to set-up and protective adjustments shall be protected by key-lockout.

5. The following operator monitoring and control devices for the inverter shall be provided on the face of the VFD enclosure, either as discrete devices or as part of a multi-function microprocessor-based keypad access device:

a. AUTO/HAND selection switch

b. While in AUTO, the inverter shall operate from the remote ethernet input, and while in HAND control shall operate from a local speed potentiometer.

c. speed indicator calibrated in percent speed

d. inverter fault trip pilot light and output alarm contacts

e. trip reset pushbutton

f. RUN and OFF indicating lights

g. Provide other controls and readouts as indicated on the Elementary Schematics indicated on the Drawings.

J. Properly identified screw type terminal boards shall be provided for interconnection to remote controls and instrumentation

K. Pilot devices, control relays, time delay relays, elapsed time meters, and indicators provided as a part of the VFD equipment package shall meet the applicable requirements of Section 26 05 15 – Local Control Stations and Miscellaneous Electrical Devices.

2.3 HARMONIC ANALYSIS FOR DRIVES

A. The CONTRACTOR shall perform a harmonic study of the facilities included in this Project.

B. The following assumptions shall be utilized for the harmonic analysis:

1. The distribution system is a "general" system as classified by IEEE 519 under low voltage systems.

2. Assume 90 percent of total plant operating load is motor load and 10 percent is resistive.

3. Assume a 70 percent plant diversity factor (i.e., 70 percent of the total plant load is operating), with motors other than VFDs operating at 90 percent of their nameplate horsepower.

4. Assume all VFDs are operating except:

    a. One of the 200hp Reuse pumps

    b. One of the Effluent Return pumps

5. Report

    a. Results of the harmonic analysis shall be submitted prior to VFD shipment.

    b. Excessive harmonic distortion shall be specifically denoted.

    c. Corrective measures shall be submitted for action by the ENGINEER.

2.4 SPARE PARTS

A. The CONTRACTOR shall furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number.

B. Modified Parts

1. At any time prior to Substantial Completion, the CONTRACTOR shall notify the ENGINEER in writing about any manufacturer's modification of spare part numbers, interchangeabilities, or model changes.

2. If the ENGINEER determines that the modified parts no longer apply to the equipment provided, the CONTRACTOR shall furnish other applicable parts as part of the WORK.

C. The following spare parts shall be furnished:

1. Provide one set of spare power fuses of each form, voltage, and current rating.

2. Provide 10 spare control and power fuses of each type and rating.

3. Provide 10 panel lamps of each type (form, voltage, and current rating).

4. Provide one of each type of circuit board, as applicable:

    a. control board

    b. power board

    c. diode bridge

d. transistor module

5. Provide one of each size and type power diode and transistor.

6. Provide one set of any special tools required for maintenance of the VFD units

2.5 Manufacturers, or equal

A. **Eaton**

B. **Rockwell Automation**

PART 3 -- EXECUTION

3.1 MANUFACTURER'S SERVICES

A. General

1. An authorized service representative of the manufacturer shall be present at the Site for 3 Days to furnish the services listed below.

2. For the purpose of this Paragraph, a Day is defined as an 8-hour period excluding travel time.

B. The authorized service representative shall supervise the following and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:

1. installation of the equipment

2. inspection, checking, and adjusting the equipment

3. startup and field testing for proper operation

4. performing field adjustments such that the equipment installation and operation comply with requirements

C. Instruction of OWNER's Personnel

1. The authorized representative shall instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with test equipment.

2. The instruction shall be specific to the VFD models provided.

3. Training shall be scheduled a minimum of 3 weeks in advance of the first session.

4. Training shall include individual sessions for 4 shifts of plant personnel.

5. Proposed training materials shall be submitted for review, and comments shall be incorporated.

6. Training materials shall remain with the trainees.

7. The OWNER may videotape the training for later use with the OWNER's personnel.

3.2 INSTALLATION

A. Conduit stub-ups for interconnected cables and remote cables shall be located and terminated in accordance with the drive manufacturer's recommendations.

B. Programming

1. The CONTRACTOR shall perform programming of drive parameters required for proper operation of the VFDs included in this project.

2. Submit records of programming data in the equipment Technical Manual, including setup and protective settings.

3.3 FIELD TESTING

A. Testing, checkout, and startup of the VFD equipment in the field shall be performed under the technical direction of the manufacturer's service engineer.

B. Under no circumstances shall any portion of the drive system be energized without authorization from the manufacturer's representative.

C. Verify proper operation of control logic in every mode of control.

D. Harmonic Analysis

1. The CONTRACTOR shall test the completed installation for actual harmonic distortion at the point of common coupling.

2. Harmonic analysis shall be performed in accordance with IEEE 519 - Harmonic Control and Reactive Compensation of Static Power Converters at unit full load using a harmonic analyzer by **Fluke**, or equal

3. Tests shall demonstrate that the harmonic voltage and current distortion levels at the point of common coupling do not exceed a magnitude of 5 percent of the fundamental, with the maximum number of drives, as permitted by the process, in operation and in conformance with the applicable requirements of IEEE-519.

4. Provide a report that shall include the following:

a. expected harmonic voltage (THD) through the 35th harmonic, calculated with isolation transformers

b. actual RMS value and measured percentage of the THD in the field

c. suggested corrective action(s) where measured harmonics exceed the limits specified herein

END OF SECTION

SECTION 26 41 23
LIGHTNING PROTECTION SYSTEM

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR, through a qualified Subcontractor, shall design and provide a lightning protection system, complete and operable, as indicated in accordance with the Contract Documents.

B. The lightning protection Subcontractor shall be certified by the Lightning Protection Institute (LPI), for both the design and the installation of the lightning protection system.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes

NFPA 780	Standard for the Installation of Lightning Protection Systems
NFPA 70	National Electric Code
UL 96A	Lightning Protection Components
LPI-175	Lightning Protection Institute Installation Code

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings in accordance with the requirements of Sections 01 33 00 – Contractor Submittals and 26 00 00 – Electrical Work, General.

1. Products: Furnish manufacturer's catalog data for all materials.

2. Drawings

a. Furnish a scaled drawing of the facility showing the lightning protection system.

b. The drawing shall show, at a minimum:

1) the location of air terminals

2) the routing of conductors

3) connections to the electrical grounding system and ground rods

4) details of air terminal mounting and bonding to vents, chimneys, antennas, and other metallic structures

3. Cross-reference the materials provided with the manufacturer's catalog numbers and cuts.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Products shall be UL-listed for use in lightning protection systems.

B. Products shall be Class I for structures not greater than 75 feet high and Class II for structures higher than 75 feet.

C. Air terminals for aluminum roofs or structures shall be of aluminum construction.

D. Air Terminals

1. Air terminals shall project a minimum of 10 inches above the objects protected, and shall be located at intervals not exceeding 20 feet along ridges and around the perimeter of flat roof or gently sloping roofs.

2. Flat or gently sloping roofs exceeding 50 feet in width shall be provided with additional air terminals at intervals not exceeding 50 feet on the flat or gently sloping area.

3. Locate air terminals within 24 inches of the roof edge and outside corners of the protected area.

4. Provide air terminals for metal stacks, flues, and mechanical equipment having a metal thickness of less than 3/16 inch and not within a zone of protection of an air terminal.

5. Equipment with a metal thickness 3/16 inch or greater shall be bonded in accordance with code requirements.

6. Air terminals shall be No. 71, 1/2-inch by 24-inch (or longer, as required), constructed of solid copper, and shall use air terminal bases of cast bronze construction for non-aluminum roofs.

E. Conductors

1. Structures Less than 75 Feet High

a. With Aluminum Roofs

1) Main size conductors on the roof shall be No. A28, Class I aluminum lightning conductor, consisting of 28 strands of 14 AWG aluminum wire weighing 115 lbs. per 1000 feet.

2) Secondary bonding conductors shall be No. A10, secondary bonding conductor, consisting of 10 strands of 14 AWG aluminum wire.

3) Down Conductors

a) Down conductors shall be No. 29, Class I copper lightning conductor.

b) Conceal down conductors in exterior wall construction.

c) Use bimetallic connectors for the transition from aluminum roof conductors to copper down conductors.

4) Provide buildings over 60 feet high with a conductor counterpoise cable constructed of 29/17 copper in conformance with NFPA code requirements.

b. With Non-Aluminum Roofs

1) Main size conductors on the roof shall be No. 29, Class I copper lightning conductor, consisting of 29 strands of 17 AWG copper wire weighing 190 lbs. per 1000 feet.

2) Secondary bonding conductors shall be No. 14, secondary bonding conductor, consisting of 14 strands of 17 AWG copper wire.

3) Down Conductors

a) Down conductors shall be No. 29, Class I copper lightning conductor.

b) Conceal down conductors in exterior wall construction.

4) Provide buildings over 60 feet high with a conductor counterpoise cable constructed of 29/17 copper in conformance with NFPA code requirements.

2. Structures Higher than 75 Feet

a. With Aluminum Roofs

1) Main size conductors on the roof shall be No. A37, Class II aluminum lightning conductor, consisting of 37 strands of 13 AWG aluminum wire weighing 190 lbs. per 1000 feet.

2) Secondary bonding conductors shall be No. A10, secondary bonding conductor, consisting of 10 strands of 14 AWG aluminum wire.

3) Down Conductors

a) Down conductors shall be No. 28, Class II copper lightning conductor.

b) Conceal down conductors in exterior wall construction.

c) Use bimetallic connectors for the transition from aluminum roof conductors to copper down conductors.

4) Provide buildings over 60 feet high with a conductor counterpoise cable constructed of 28/14 copper in conformance with NFPA code requirements.

b. With Non-Aluminum Roofs

1) Main size conductors on the roof shall be No. 28, Class II copper lightning conductor, consisting of 28 strands of 14 AWG copper wire weighing 375 lbs. per 1000 feet.

2) Secondary bonding conductors shall be No. 14, secondary bonding conductor, consisting of 14 strands of 17 AWG copper wire.

3) Down Conductors

a) Down conductors shall be No. 28, Class II copper lightning conductor.

b) Conceal down conductors in exterior wall construction.

4) Provide buildings over 60 feet high with a conductor counterpoise cable constructed of 28/14 copper in conformance with NFPA code requirements.

F. Miscellaneous Hardware

1. Provide miscellaneous hardware as may be required for the installation of the lightning protection system.

2. The hardware shall be compatible with the indicated air terminal and conductor materials.

3. Nuts, bolts, and other fasteners shall be constructed of stainless steel.

G. Corrosion Protection

1. Provide corrosion protection at the junctions of dissimilar metals and at locations where the components of the lighting protection system may be subjected to corrosion.

2. Use bimetallic connectors and fittings for splicing and bonding dissimilar metals.

3. Bimetallic connectors shall be located not less than 18 inches above grade.

4. Copper components within 24 inches of a chimney or vent emitting corrosive gases shall be protected by a hot-dipped lead coating or by another method as approved by the ENGINEER.

H. Grounding Materials

1. Ground rods and ground conductors shall conform to the requirements of Section 26 05 26 – Grounding.

2. Down conductors shall be connected to the ground rods using exothermic weld connections.

I. Structural Steel System

1. Structural steel may be substituted for down conductors.

2. The main steel columns shall be grounded an average maximum distance of 60 feet using Class II material.

3. Roof penetrations from steel to perimeter cables shall be at intervals not exceeding 100 feet in accordance with the requirements of UL 96A, LPI 175, and NFPA 780.

4. Use exothermic welds for steel connections.

PART 3 -- EXECUTION

3.1 GENERAL

A. The lightning protection system shall be installed in accordance with applicable code requirements by a Subcontractor certified in the following organizations:

1. NFPA

2. LPI

3. UL

B. Bends in conductors shall be gradual, utilizing a radius of 8-inches or greater and forming an angle of at least 90 degrees.

3.2 ROOF PENETRATIONS

A. Roof penetrations shall be made using a conduit sleeve passing through a pitch pocket.

B. The CONTRACTOR shall construct the pitch pockets in such a way as to maintain the roofing warranty required under Division 7 in full force.

3.3 INTERCONNECTIONS OF METALS

A. Metal bodies within 6 feet of the conductor shall be bonded to the system with approved fittings and conductor.

B. Bonding of metallic objects and systems at roof levels and elsewhere on the structure shall be complete.

C. The primary bonds for metal bodies of conductance, which shall include the following items, shall be bonded with appropriate fittings and full-size conductor:

1. roof exhaust fans

2. HVAC units with related piping ductwork

3. exhaust vents and other roof piping systems

4. cooling towers and rail systems

5. window-washing tracks

6. antenna masts for TV, radio, or microwave

7. flag poles

8. roof handrails

9. decorative screens

10. roof ladders

11. skylights

12. metal plumbing stacks

D. Exterior architectural metal fascia, curtain walls, or mullions, which extend the full height of the structure, shall be bonded, if not inherently bonded through the building frame.

E. Metal Bodies of Conductance

1. Metal bodies of inductance located within 6 feet of a conductor or object with secondary bonds shall be bonded with secondary cable and fittings.

2. Typical of these are:

a. roof flashings

b. parapet coping

c. gravel guards

d. isolated metal building panels or siding

e. roof drains and down spouts

f. roof insulation vents

g. other sizeable miscellaneous metal fabrications

3.4 INSPECTION AND ACCEPTANCE

A. The lightning protection system shall be inspected, tested, and certified.

B. The CONTRACTOR shall retain the services of an independent inspector.

C. An LPI/UL Certificate of Inspection shall be furnished to the ENGINEER.

END OF SECTION

SECTION 26 43 00
SURGE PROTECTION DEVICES (SPD)

PART 1 -- GENERAL

1.1 THE SUMMARY

A. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install surge protective devices (SPD).

B. SPDs furnished under this Section shall be ANSI/UL 1449 Type 2 integrating both surge suppression and high-frequency noise filtering suitable for use on low-voltage distribution systems.

C. The requirements of Section 26 00 00 – Electrical Work, General, apply to the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Standards:

1. ANSI/UL 1449, Fourth Edition, Safety Surge Protective Devices

2. IEEE C62.41.1, Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits

3. IEEE C62.45, Recommended Practice on Surge Testing for Equipment Connect to Low-Voltage (1000V and Less) AC Power Circuits

4. UL 1283, Safety Electromagnetic Interference Filters

5. NFPA 70, National Electric Code

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 26 00 00 – Electrical Work, General.

B. Shop Drawings

1. Electrical and mechanical drawings for each type of unit, showing electrical ratings, dimensions, mounting provisions, connection details, and layout diagrams.

C. Product Data:

1. Manufacturer’s technical information, including catalog information.

2. Manufacturer's technical specifications with assembly and component ratings.

D. Certifications: Certification that SPD devices comply with standards referenced in this Section.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Shall have at least five (5) years' experience manufacturing and servicing products substantially similar to those required and shall be able to submit documentation of at least 5 installations in satisfactory operation for at least five (5) years each.

B. Component Supply and Compatibility:

1. Obtain all products included in this Section regardless of component manufacturer from a single SPD manufacturer.

2. SPD manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all components furnished under this Section.

3. Components shall be suitable for the specified service conditions and shall be integrated into overall assembly by SPD manufacturer.

PART 2 -- PRODUCTS

2.1 GENERAL

A. SPD shall be modular, high-energy, parallel design with fast-acting transient voltage suppression using metal oxide varistors. Equipment shall provide noise attenuation with electromagnetic interference filter.

B. SPD shall be suitable for operation under the following environmental conditions:

1. Relative Humidity: Zero to 95%, non-condensing

2. Frequency: 47 to 63 Hz

3. Temperature: Zero to 149°F

4. SPD operating voltage shall be suitable for the associated SPD location(s).

5. SPD shall be suitable for internal and external mounting. SPD shall be factory-mounted and integrated into distribution equipment specified under the following Sections:

a. Section 26 00 00 – Electrical Work, General

b. Section 26 11 10 – Low Voltage Switchgear

c. Section 26 12 16 – Panelboards and General Purpose Dry Type Transformers

C. SPD shall include a surge suppression path for each mode as required for the system configuration. Each mode shall be individually fused and equipped with thermal cutouts. SPD short-circuit current rating shall be 200 kA. Protection modes shall include, to the extent applicable, the following:

1. Line-to-line

2. Line-to-neutral

3. Line-to-ground

4. Neutral-to-ground

D. SPD shall include electromagnetic interference/radio frequency interference (EMI/RFI) noise rejection filter with attenuation up to 30 dB from 10 kHz to 100 MHz.

E. SPDs and components in the operating path shall have maximum continuous operating voltage greater than 115% of nominal system operating voltage.

F. ANSI/UL 1449 minimum withstand rating shall be 20 kA per pole, and ANSI/UL 1449 voltage protection rating for SPD shall not exceed the following:

Modes	**208Y/120**	**480Y/277**
L-N,L-G, N-G	800	1200
L-L	1200	2000

G. SPD surge capacity based upon IEEE C62.41 location category shall, as a minimum, be the following:

Category	**Application**	**Per Phase**	**Per Mode**
C	Service entrance	240 kA	120 kA
B	High exposure locations (distribution equipment)	160 kA	80 kA
A	Branch locations	120 kA	60 kA

H. Provide SPD equipped with the following accessories:

1. Surge counter with display for indicating the number of surges detected.

2. LED indicators for monitoring device status.

3. Audible alarm and silence switch for indicating an inoperative condition.

4. Dry contacts, “form C”, for remote annunciation of unit status.

I. Source Quality Control: Perform manufacturer’s standard factory tests on equipment. Tests shall be in accordance with ANSI/UL 1449.

J. Manufacturers: **General Electric, Schneider Electric/Square D Company, or equal**

PART 3 -- EXECUTION

3.1 GENERAL

A. Install SPD in accordance with equipment manufacturer's written recommendations and instructions and the Contract Documents.

B. Where an SPD cannot be installed integral with the equipment to which it is connected, conductor length between suppressor and connection point shall be as short and as straight as possible.

END OF SECTION

SECTION 26 50 00
LIGHTING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. Provide luminaires and accessories, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Codes

NFPA 70	National Electric Code
NEMA 250	Enclosures for Electrical Equipment (1,000 Volts Maximum)
UL-595	Standard for Safety Marine-Type Electric Lighting Fixtures
UL-924	Standard for Safety Emergency Lighting and Power Equipment

1.3 CONTRACTOR SUBMITTALS

A. Furnish the following product information in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

B. Furnish the following information:

1. Interior Luminaires

a. Catalog data sheets and photos

b. Luminaire finish and metal gauge

c. Lens material, pattern, and thickness

1) Candlepower distribution curves in 2 or more planes

d. Candlepower chart, 0 to 90 degrees

e. Lumen output chart

f. Average maximum brightness data in foot-lamberts

g. Coefficients of utilization for zonal cavity calculations

h. Mounting or suspension details

i. Heat exchange and air handling data

2. Exterior Luminaires

    a. Catalog data sheets and photos

    b. Luminaire finish and metal gauge

    c. Lens material, pattern, and thickness

    d. IES lighting classification and isolux diagram

    e. Fastening details to wall

3. Lamps

    a. Voltages

    b. Colors

    c. Approximate life (in hours)

    d. Approximate initial lumens

    e. Lumen maintenance curve

    f. Lamp type

4. Photocells

    a. Voltage and power consumption

    b. Capacity

    c. Contacts and time delay

    d. Operating levels

    e. Enclosure type and dimensions

    f. Temperature range

PART 2 -- PRODUCTS

2.1 LUMINAIRES

A. General

1. Additional Work requirements are indicated in the Luminaire Schedule on the Drawings.

2. Where normal use lighting is provided with integral emergency battery option, provide additional hot (unswitched) wire to the luminaire.

B. Provide minimum 18 AWG wire leads with fused inputs.

C. Provide components that are accessible and replaceable without removing the luminaire from the ceiling.

D. Exterior Installations

1. Installations shall be UL-labeled as "Suitable for Wet Locations."

2. When factory-installed photocells are provided, the entire assembly shall be UL-labeled.

E. Emergency Lighting

1. Power Pack

a. Self-contained

b. 120/277 V

c. Battery as per luminaire schedule

d. Indicator switch in accordance with the requirements of UL 924

2. Lighted, push-to-test pushbutton and indicator

3. Capability of providing full illumination for 1-1/2 hours in emergency mode

4. Capability of full recharge in 24 hours, automatically initiated upon resumption of normal line voltage

5. Capability of protecting against excess charging and discharging

6. Solid state charger

7. Normal and emergency led indicating lights

8. Mounting stand (as applicable)

9. Provide NEMA-rated enclosures in accordance with the area classifications in which they are installed.

F. Exit Signs

1. Internally illuminated

2. Universal mounting type

3. Battery as per luminaire schedule

4. Battery charger

5. LED-type emergency and normal indicating lights

6. Press-to-test button

7. Directional arrows

2.2 LAMPS

A. See Luminaire Schedule

2.3 LIGHTING CONTROL

A. Photocell

1. Photo Control: automatic ON-OFF switch

2. Housing: self-contained; die-cast aluminum; unaffected by moisture, vibration, or temperature changes

3. Settings: ON at dusk; OFF at dawn

4. Provide a time delay feature in order to prevent false switching.

5. Field-adjustable to control operating levels

6. Manufacturer, or Equal

a. **Tork**

b. **Paragon**

PART 3 -- EXECUTION

3.1 LUMINAIRES

A. General

1. Install in accordance with the manufacturer's recommendations.

2. Provide necessary hangers, pendants, canopies, and other accessories.

3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to the building as required to safely mount the luminaire.

4. Install the luminaire plumb and level.

5. The mounting heights indicated for wall-mounted or pendant-mounted luminaires are from the bottom of the luminaire to finished floor or finished grade, whichever is applicable.

6. Install each luminaire outlet box with a galvanized stud.

B. Pendant Mounting

1. Provide swivel-type hangers and canopies to match the luminaires, unless otherwise indicated.

2. Space single-stem hangers on continuous-row fluorescent luminaires 48 inches apart.

3. Provide twin-stem hangers on single luminaires.

C. Unfinished Areas

1. Locate the luminaires to avoid conflicts with other building systems and blockage of the luminaire light output.

2. Luminaire Suspension

a. Provide 3/8-inch threaded galvanized steel hanger rods.

b. Scissor-type hangers will not be accepted.

3. For attachments to steel beams, provide flanged beam clips and straight or angled hangers.

3.2 LAMPS

A. Within each luminaire, provide the number and type for which the luminaire is designed, unless otherwise indicated.

3.3 CLEANUP

A. Remove labels and other markings, except the UL listing mark.

B. Wipe the luminaires inside and out in order to remove construction dust.

C. Clean the luminaire plastic lenses with an antistatic cleaner only.

D. Touch up painted surfaces of the luminaires and the poles with matching paint provided by the manufacturer.

E. Replace defective lamps at the Date of Substantial Completion.

END OF SECTION

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DIVISION 31
EARTHWORK

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SECTION 31 10 00
SITE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section includes all those measures required during the Contractor's initial move onto the site to protect existing fences, structures and associated improvements, streets, and utilities downslope of construction areas from damage due to boulders, trees or other objects dislodged during the construction process: clearing, grubbing and stripping; and regrading of areas to receive embankment fill.

B. The Contractor is required to protect and preserve all things designated to remain. Where Contractor's operation causes damage or injury to trees and plants designated to remain, an arborist or other qualified professional shall be employed by the Contractor, at no additional cost to the Owner, to repair the damage or provide adequate replacement to the Owner's satisfaction where damage is beyond repair.

1.2 SITE INSPECTION

A. Prior to moving onto the Project site, the Contractor shall inspect the site conditions and review maps of the existing plant site and off-site pipeline routes and facilities delineating the Owner's property and right-of-way lines.

B. Contractor shall submit photographs or videotape, sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site preparation.

C. The Contractor shall identify and accurately locate utilities and other subsurface structural, electrical, and mechanical conditions. Existing conditions shall be incorporated into the record drawings for the project.

1.3 DEFINITIONS

A. The following definitions apply to the Work of this Section:
   1. Clearing is defined as cutting trees, removing fences and posts, removing curbs and other improvements to prepare the site for grubbing and stripping.
   2. Grubbing is defined as the below grade part of clearing to remove roots, small piping, irrigation systems, etc., to prepare the site for stripping.
   3. Stripping is defined as removing a surface layer of soil and organic material, sod, topsoil, and other unsuitable material as defined in Section 31 23 00 – Earthwork, to a depth that earthwork can proceed.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Provide erosion-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Locate and clearly flag trees and vegetation to remain or to be relocated.

D. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TREE PROTECTION

A. Erect and maintain a temporary fence around drip line of individual trees or around perimeter drip line of groups of trees to remain. Remove fence when construction is complete.
   1. Do not store construction materials, debris, or excavated material within drip line of remaining trees.
   2. Do not permit vehicles, equipment, or foot traffic within drip line of remaining trees.

B. Do not excavate within drip line of trees, unless otherwise indicated.

C. Where excavation for new construction is required within drip line of trees, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
   1. Cover exposed roots with burlap and water regularly.
   2. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
   3. Coat cut faces of roots more than 1-1/2 inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
   4. Cover exposed roots with wet burlap to prevent roots from drying out. Backfill with soil as soon as possible.

D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Engineer.
   1. Employ a qualified arborist, licensed in jurisdiction where project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
   2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the qualified arborist.

3.3 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

1. Owner will arrange to shut off indicated utilities when requested by Contractor.
2. Arrange to shut off indicated utilities with utility companies.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
1. Notify Engineer not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Engineer's written permission.

C. Excavate for and remove underground utilities indicated to be removed.

3.4 PRIMARY PLANT SITE ACCESS

A. Develop any necessary access to the site, including barrier facilities to be installed at the beginning of construction in order to prohibit entry of unauthorized persons.

B. Utility Interference: Where existing utilities interfere with the Work of this Section, notify the Engineer and work around the interferences until a directive is issued.

3.5 CLEARING, GRUBBING, AND STRIPPING

A. All construction areas shall be cleared of grass and weeds to at least a depth of six inches and cleared of structures, concrete or masonry debris, trees, logs, upturned stumps, loose boulders, and any other objectionable material of any kind which would interfere with the performance or completion of the Work, create a hazard to safety, or impair the Work's subsequent usefulness or obstruct its operation. Loose boulders within 10 feet of the top of cut lines shall be incorporated in landscaping or removed from the site. Trees and other natural vegetation outside the actual lines of construction shall be protected from damage during construction, as directed by the Engineer.

B. Within the limits of clearing, the areas below the natural ground surface shall be grubbed to a depth necessary to remove all stumps, roots, buried logs, and all other objectionable material. Debris or waste shall be totally removed if they are found on the site. All objectionable material from the clearing and grubbing process shall be removed from the site and wasted in approved safe locations in compliance with state and federal regulations.

C. The area to be affected by construction that have not been pre-excavated to the subgrade elevation shall be removed and placed in the designated stockpile areas, and/or incorporated into landscaped areas or other nonstructural embankments.

D. For all areas that have not been previously disturbed, including staging areas and temporary construction easements, topsoil-salvaging operation shall immediately follow clearing operations. The area shall be stripped of topsoil to a depth of 8 inches. Unsuitable materials, specified in Section 31 23 00, shall not be considered topsoil. The Contractor shall strip to the depth indicated regardless of the material encountered. All stripped topsoil shall be stockpiled within stripped areas in stockpiles not to exceed 15 feet in height. Vegetation shall be ground or chipped to a mulching consistency and mixed with the stripped soil. Stockpiles shall be placed away from high construction traffic areas and shall be fenced and signed to prevent accidental use as fill prior to topsoil replacement.

E. Upon completion of Work within the construction areas stripped of topsoil, the stored topsoil shall be respread over the disturbed areas. Topsoil shall be spread in about a 6-inch layer. Respread topsoil shall match the existing terrain as much as possible. Interfaces between restored disturbed areas and undisturbed areas shall be chain dragged to eliminate obvious edges. All tracks and equipment marks shall be chain dragged or hand raked away. Replaced topsoil shall be thoroughly watered for dust control upon completion of the respreading operations. Once topsoil replacement has been completed, no vehicles or other motorized equipment shall be allowed to travel on the finished surface.

F. Unless otherwise indicated, native trees larger than three inches in diameter at the base shall not be removed without the Engineer's approval. The removal of any trees, shrubs, fences, or other improvements outside of rights-of-way, if not necessary for the Contractor's choice of means and methods, shall be arranged with the property owner and be removed and replaced at no increased cost to the Owner.

G. Except in areas to be excavated, holes and other holes resulting from Work of this section shall be backfilled with suitable material in accordance with Section 31 23 00 – Earthwork.

3.6 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincides with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.

3.7 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials, including trash and debris, and legally dispose of them off Owner's property.

END OF SECTION

SECTION 31 23 00
EARTHWORK

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall perform all earthwork indicated and required for construction of the Work, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

29 CFR 1926	OSHA Safety and Health Regulations for Construction
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM D 422	Method for Particle-Size Analysis of Soils
ASTM D 1556	Test Method for Density of Soil in Place by the Sand-Cone Method
ASTM D 1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3) (2,700 kN-m/m^3)
ASTM D 1633	Test Method for Compressive Strength of Molded Soil-Cement Cylinders
ASTM D 2419	Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2487	Classification of Soils for Engineering Purposes
ASTM D 2901	Test Method for Cement Content of Freshly Mixed Soil Cement
ASTM D 2922	Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods
ASTM D 4253	Test Methods for Maximum Index Density of Soils using a Vibratory Table
ASTM D4254	Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D 4318	Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D4832	Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D 5971	Practice for Sampling Freshly Mixed Controlled Low Strength Material (CLSM)
ASTM D 6023	Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)
ASTM D 6024	Test Method for Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application
ASTM D 6103	Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)

1.3 CONTRACTOR SUBMITTALS

A. The Contractor's attention is directed to the provisions of Subpart P, 29 CFR 1926 of the OSHA Safety and Health Standards for Construction, which relate to protection of employees in excavations. The Contractor shall submit, for information to the Engineer, the project excavation plan and the name of the Contractor's competent person, prior to commencing any excavation.

B. Submit samples of all materials proposed to be used in the work in accordance with the requirements in Section 01 33 20 - Contractor Submittals. Sample sizes shall be as determined by the testing laboratory.

C. Submit dewatering and water removal plan prior to performing any dewatering or water removal.

PART 2 - PRODUCTS

2.1 SUITABLE FILL AND BACKFILL MATERIAL REQUIREMENTS

A. General: Fill, backfill, and embankment materials shall be suitable material.

B. Suitable Materials: Suitable material is defined as selected or processed clean, well graded earth material, sands and gravels free of excessive fines, less than 20 percent rock and boulders larger than 4 inches, grass, roots, brush, vegetation, or other deleterious materials.

C. Fill and backfill materials within 6 inches of any structure or pipe shall be smaller than 1 inch in any dimension.

1. Suitable materials may be obtained from onsite excavations, may be processed onsite materials, or may be imported. If imported materials are required by this Section or to meet the quantity requirements of the Project, provide the imported materials at no additional expense to the Owner, unless a unit price item is included for imported materials in the bidding schedule. Onsite materials shall be stockpiled and segregated prior to use.

2. The following types of suitable materials are defined:

Type A (Granular Backfill): Crushed rock or gravel, and sand well graded and readily compacted, non-plastic, meeting the following gradation requirements:

Sieve Size	Percentage Passing
1-inch	100
No. 40	15 - 60
No. 200	0 - 15

Type B (Crushed Rock): Manufactured angular, crushed rock, non-plastic, meeting the following gradation requirements:

Sieve Size	Percentage Passing
3/8-inch	100
No. 4	30 - 50
No. 200	0 - 5

Type C (Sand Backfill): Sand non-plastic, meeting the following gradation requirements:

Sieve Size	Percentage Passing
3/4-inch	100
No. 4	80 - 100
No. 10	30-50
No. 40	10-30
No. 200	7 - 15

Squeegee is not acceptable as sand backfill.

Type D (Select Backfill): Suitable material that can be readily compacted and meets the requirements of AASHTO M 145 classification A-1-a, non-plastic, well graded with a maximum particle size of 2 inches.

Sieve Size	Percentage Passing
2-inch	100
No. 10	30-50
No. 40	15-30
No. 200	0 - 15

Type E (Pea Gravel Backfill): Crushed rock or gravel with 100 percent passing a 1/2-inch sieve and not more than 10 percent passing a No. 4 sieve.

Type F (Drainrock): Crushed rock or gravel conforming to one of the following gradation requirements, as shown on the Drawings or approved by the Engineer:

	Percentage Passing		
Sieve Size	3-inch Max.	2-inch Max.	3/4-inch Max.
3-inch	100	-	-
2-inch	90 - 100	100	-
1-1/2 inch	70 - 100	90 – 100	-
3/4 inch	0 - 50	0 – 15	100
1/2-inch	-	-	95 - 100

3/8-inch	0 - 10	0 - 5	70 - 100
No. 4	0 - 25	-	-
No. 8	0 - 5	-	-
No. 200	0 - 3	-	0 - 3

Type G (Type II Aggregate Base): Well-graded, clean, hard, tough, durable, and sound mineral aggregates consisting of crushed stone, or crushed gravel, free of organic matter and contamination from chemical or petroleum products meeting State specification requirements and conforming to the following Table and gradations:

Aggregate Properties			
	Aggregate Class		
	A	**B**	
Dry Rodded Unit Weight	Not less than 75 lb/ft^3		AASHTO T 19
Liquid Limit/Plastic Index	Non-plastic	PI ≤ 6	AASHTO T 89 AASHTO 90
Aggregate Wear	Not to exceed 50 percent		AASHTO T 96
Gradation	Table 2		AASHTO T 11 AASHTO T 27
CBR with a 10 lb surcharge measured at 0.20 inch penetration	70% Minimum	N/A	AASHTO T 193
Two Fractured Faces	50% Min	N/A	AASHTO T 335

Sieve Size	Percentage Passing
1 ½ -inch	100
1-inch	90 - 100
3/4-inch	70 - 85
1/2-inch	65 - 80
3/8-inch	55 - 75
No. 4	40 - 60
No. 16	25 - 40
No. 200	8 - 13

Type H (Graded Drainrock): Graded drainrock shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting and drying. The material shall be uniformly graded and shall meet the following gradation requirements:

Sieve Size	Percentage Passing
1-inch	100
3/4 inch	90 - 100
3/8-inch	40 - 100
No. 4	25 - 40
No. 8	18 - 33
No. 30	5 - 15
No. 50	0 - 7
No. 200	0 - 3

Type I: (Levee Material): Clayey sand to sandy clay obtained from off-site borrow sources or from onsite excavations, processed to the extent required to produce a material with a maximum size of 4 inches, well-graded from coarse to fine, and free from roots, sticks, organic matter, concrete, asphalt and other deleterious material. Levee material shall meet the following gradation requirements:

Sieve Size	Percentage Passing
4-inch	100
No. 4	50 - 70
No. 200	30 - 50

Type J (Cement-Treated Backfill): Material which consists of Type F material, or any mixture of Types B, C, G, and H materials which has been cement-treated so that the cement content of the material is not less than 5 percent by weight when tested in accordance with ASTM D 2901. The ultimate compressive strength at 28 days shall be not less than 400 psi when tested in accordance with ASTM D 1633.

Type K (Topsoil): Stockpiled topsoil material which has been obtained at the site by removing soil to a depth as defined in Section 31 10 00 - Site Preparation. Removal of the topsoil shall be done after the area has been stripped of vegetation and debris.

Type M (Aggregate Subbase): Crushed rock aggregate subbase material non-plastic that can be compacted readily by watering and rolling to form a stable base. The sand equivalent value shall not be less than 18 and shall meet one of the following gradation requirements, as shown on the Drawings or approved by the Engineer:

	Percentage Passing	
Sieve Size	3-inch Max.	2-inch Max.
3-inch	100	-
2-inch	90 - 100	100
1-1/2 inch	-	95 - 100
1-inch	70 - 90	-
No. 4	30 - 65	30 - 65
No. 16	15 - 40	15 - 40
No. 200	2 - 12	2 - 12

Type N (trench plug): Low permeable fill material, a nondispersable clay material having a minimum plasticity index of 10.

Type O (Controlled Low Strength Material (CLSM)): CLSM shall consist of a mixture of portland cement, aggregate, fly ash, water, and approved admixtures conforming to the following requirements:

3. Blended Hydraulic Cement: Comply with ASTM C595, Type IL (10) (MS), grey color.
4. Aggregate: Clean imported sand and gravel or selected material from the excavation, imported material, or a combination thereof as approved by the Engineer. Maximum aggregate size shall be 1 to 3 inches. The soluble sulfate content of aggregate in the mixture shall not exceed 0.3 percent by dry weight.
5. Water: Potable quality.
6. Fly Ash: Class C, ASTM C 618 or approved alternate.

7. The minus 200 sieve fraction shall be nonplastic, as defined by ASTM D 4318. By this standard, a soil is considered nonplastic if either the liquid or plastic limit cannot be determined, or if the plastic limit is equal to or greater than the liquid limit.
8. Proportion the CLSM to be a flowable, nonsegregating, self-consolidating low shrink slurry. The Contractor shall determine the materials and proportions used to meet the requirements of these Specifications.
9. The unconfined compressive strength at 7 days shall be a minimum of 100 psi and a maximum of 300 psi. Contractor shall form a minimum of six test cylinders with proposed materials to confirm design strength and mix design. Four of the cylinders shall be broken at 7 days in conformance with applicable concrete cylinder specifications and results provided to Engineer. The remaining two cylinders shall be broken by Contractor at discretion of Engineer. Initial mix design and cylinder breaks shall be completed at least 21 days prior to use of the material on the jobsite. Final mix approval and use of the material shall not occur prior to confirmation of strength by the cylinder breaks.
10. The temperature of the CLSM discharged into the trench shall be below 90 degrees F.
11. CLSM backfill under concrete structures shall be protected during curing as specified Section 03 30 00 - Cast-in-Place Concrete.
12. CLSM shall be tested in accordance with ASTM D 4832, ASTM D 5971, ASTM D 6023, and ASTM D6103

Type P: (Suitable Trench Backfill): Suitable material that can be readily compacted, with less than 35 percent passing the No. 200 sieve and a plasticity index of 10 or less.

2.2 UNSUITABLE MATERIAL

A. Unsuitable materials include but are not limited to the materials listed below.
   1. Soils which, when classified under ASTM D 2487 - Classification of Soils for Engineering Purposes, fall in the classifications of Pt, OH, CH, MH, or OL.
   2. Soils which cannot be compacted sufficiently to achieve the density indicated for the intended use.
   3. Materials that contain hazardous or designated waste materials including petroleum hydrocarbons, pesticides, heavy metals, slag, and any material which may be classified as hazardous or toxic according to applicable regulations.
   4. Soils that contain greater concentrations of chloride or sulfate ions, or have a soil resistivity or pH less than the existing onsite soils.
   5. Topsoil, except as allowed below.

2.3 USE OF FILL, BACKFILL, AND EMBANKMENT MATERIAL TYPES

A. Use the types of materials as designated herein for all required fill, backfill, and embankment construction hereunder.

B. Where these Specifications conflict with the requirements of any local agency having jurisdiction or with the requirements of a pipe material manufacturer, notify the Engineer immediately. In case of conflict between types of pipe embedment backfills, use the agency-specified backfill material if that material provides a greater degree of support to the pipe, as

determined by the Engineer. In case of conflict between types of trench or final backfill types, use the agency-specified backfill material if that material provides the greater in-place density after compaction.

C. Fill and backfill types shall be used in accordance with the following provisions:
   1. Embankment fills shall be constructed of Type P material, as defined herein, or any mixture of Type P and Type A through Type F materials.
   2. Pipe zone backfill, as defined under "Pipe and Utility Trench Backfill" below, shall consist of the following materials for each pipe material listed below.
      a. Mortar coated pipe, concrete pipe, and uncoated ductile iron pipe shall be provided with Type A or C material in the pipe zone.
      b. Coal tar enamel coated pipe, polyethylene encased pipe, tape wrapped pipe, and other nonmortar coated pipe shall be backfilled with Type C material in the pipe zone.
      c. Plastic pipe and vitrified clay pipe shall be backfilled with Type C material in the pipe zone.
      d. Where pipelines are installed on grades exceeding 4 percent, and where backfill materials are graded such that there is less than 10 percent passing a No. 4 sieve, trench plugs of Type J or N material shall be provided at maximum intervals of 200 feet unless indicated otherwise.
      e. Type O material shall be used in the pipe zone where shown on plans, specified, or required by the Engineer for special crossings or other locations, or where otherwise approved.
      f. Type E material will not be allowed for backfill within the pipe zone.
   3. Trench zone backfill for pipelines as defined under "Pipe and Utility Trench Backfill" shall be Type D backfill material.
   4. Final backfill material for pipelines under paved areas, as defined under "Pipe and Utility Trench Backfill" shall be Type G backfill material. Final backfill under areas not paved shall be the same material as that used for trench backfill.
   5. Trench backfill and final backfill for pipelines under structures shall be Type A or B, except where concrete encasement is required by the Contract Documents.
   6. Aggregate base materials under pavements shall be Type G material constructed to the thicknesses indicated. Aggregate subbase shall be Type M material.
   7. Backfill around structures shall be Type P material, or Types A through Type F materials, or any mixture thereof, except as shown.
   8. Backfill materials beneath structures shall be as follows:
      a. Drainrock materials under hydraulic structures or other water retaining structures with underdrain systems shall be Type H material.
      b. Under concrete hydraulic structures or other water retaining structures without underdrain systems, Types F, G or H materials shall be used.
      c. Under structures where groundwater must be removed to allow placement of concrete, Type F material shall be used. Before the Type F material is placed, filter type geotextile fabric shall be placed over the exposed foundation.
      d. Under all other structures, Type F, G or H material shall be used.
   9. Backfill used to replace pipeline trench overexcavation shall be a layer of Type F material with a 6-inch top filter layer of Type E material or filter fabric to prevent migration of fines for wet trench conditions or the same material as used for the pipe zone backfill if the trench conditions are not wet.

2.4 PIPELINE MARKING TAPE

A. Metallic Tape: Tape shall be minimum 5.5 mils thick aluminum foil imprinted on one side, encased in high visibility inert polyethylene jacket. Tape shall be a minimum of 6 inches wide. Imprinted lettering shall be 1 inch tall, permanent black, as indicated. Joining clips shall be manufacturer's standard tin or nickel coated. Tape shall be as manufactured by Reef Industries (Terra "D"), Allen (Detectatape), or equal.

B. Plastic Tape: Tape shall be minimum 4-mil thick polyethylene which is impervious to alkalais acids, and chemicals and solvents which are likely in the soil. Tape shall be a minimum of 6 inches wide and lettering shall be 1-inch tall permanent black on a colored background. Tape shall be manufactured by Reef Industries (Terra Tape), Allen (Markline), or equal.

C. Warning Tape: Warning tape manufactured for marking and identifying underground utilities continuously inscribed with a description of utility, colored as follows:
   1. Red; Electric.
   2. Yellow; Gas, oil, steam, and dangerous materials.
   3. Orange: Telephone and other communications.
   4. Blue: Water Systems.
   5. Green: Sewer Systems.
   6. Purple: Secondary Irrigation Systems.

2.5 MATERIALS TESTING

A. All soils testing of samples submitted by the Contractor will be done by a testing laboratory of the Owner's choice and at the Owner's expense. At its discretion, the Engineer may request that the Contractor supply samples for testing of any material used in the work.

B. Particle size analysis of soils and aggregates will be performed using ASTM D 422 - Method for Particle-Size Analysis of Soils.

C. Determination of sand equivalent value will be performed using ASTM D 2419 - Test Method for Sand Equivalent Value of Soils and Fine Aggregate.

D. Unified Soil Classification System: References in this Section to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487. The Contractor shall be bound by all applicable provisions of said ASTM D 2487 in the interpretation of soil classifications.

E. The testing for chloride, sulfate, resistivity, and pH will be done by a testing laboratory of the Owner's choice and at the Owner's expense.

PART 3 - EXECUTION

3.1 EXCAVATION – GENERAL

A. General: Except when specifically provided to the contrary, excavation shall include the removal of all materials of whatever nature encountered, including rock and all obstructions of any nature that would interfere with the proper execution and completion of the Work.

The removal of said materials shall conform to the lines and grades indicated or ordered. Unless otherwise indicated, the entire construction site shall be stripped of all vegetation and debris, and such material shall be removed from the site prior to performing any excavation or placing any fill. Furnish, place, and maintain all supports and shoring that may be required for the sides of the excavations. Excavations shall be sloped or otherwise supported in a safe manner in accordance with safety requirements of the requirements of OSHA Safety and Health Standards for Construction (29CFR1926).

B. Maximum Length of Open Trench: The maximum length of open trench in urban and rural areas shall not exceed 500-feet at each pipe installation heading beyond the end of the installed pipeline, or the requirements of the agency with jurisdiction, whichever is lesser.

C. Construction Delays: In the case of any construction delay in excess of five calendar days, whether Contractor or Owner caused, the Contractor shall backfill the excavation, install temporary paving including temporary traffic markings, and restore traffic to pre-construction condition to minimize disruption to traffic and the community at no additional cost to the Owner.

D. Removal and Exclusion of Water: Remove and exclude water, including storm water, groundwater, irrigation water, and wastewater, from all excavations. Dewatering wells, well points, sump pumps, or other means shall be used to remove water and continuously maintain groundwater at a level at least 2 feet below the bottom of excavations before the excavation work begins at each location. Water shall be removed and excluded until backfilling is complete and all field soils testing has been completed.

3.2 STRUCTURE, ROADWAY, AND EMBANKMENT EXCAVATION

A. Excavation Beneath Structures and Embankments: Except where otherwise indicated for a particular structure or ordered by the Engineer, excavation shall be carried to the grade of the bottom of the footing or slab. Where indicated or ordered, areas beneath structures or fills shall be overexcavated. The subgrade areas beneath embankments shall be excavated to remove not less than the top 6 inches of native material and where such subgrade is sloped, the native material shall be benched. When such overexcavation is indicated, both overexcavation and subsequent backfill to the required grade shall be performed. When such overexcavation is not indicated but is ordered by the Engineer, such overexcavation and any resulting backfill will be paid for under a separate unit price bid item if such bid item has been established; otherwise payment will be made in accordance with a negotiated price. After the required excavation or overexcavation has been completed, the exposed surface shall be scarified to a depth of 6 inches, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

B. Excavation Beneath Concrete Reservoirs: Excavation under reservoirs shall extend to the bottom of the drainrock layer. After such excavation has been completed, the exposed surface shall be rolled with heavy compaction equipment to 95 percent of maximum density and then graded to provide a reasonably smooth surface for placement of the drainrock. Areas under the reservoir upon which fill is to be placed shall be scarified to a depth of 6 inches, brought to optimum moisture content, and compacted to obtain 95 percent of maximum density with moisture content within plus and minus 2 percent of the optimum moisture content.

C. Excavation Beneath Paved Areas: Excavation under areas to be paved shall extend to the bottom of the aggregate base or subbase, if such base is called for; otherwise it shall extend to the bottom of the paving thickness. After the required excavation has been completed, the top 12 inches of exposed surface shall be scarified, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density. The finished subgrade shall be even, self-draining, and in conformance with the slope of the finished pavement. Areas that could accumulate standing water shall be regraded to provide a self-draining subgrade.

D. Notification of Engineer: Notify the Engineer at least 3 days in advance of completion of any structure excavation and allow the Engineer a review period of at least 1 day before the exposed foundation is scarified and compacted or is covered with backfill or with any construction materials.

3.3 PIPELINE AND UTILITY TRENCH EXCAVATION

A. General: Unless otherwise indicated or ordered, excavation for pipelines and utilities shall be open-cut trenches with widths as indicated.

B. Trench Bottom: Except when pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe zone. Excavations for pipe bells and welding shall be made as required.

C. Open Trench: The maximum amount of open trench permitted in any one location shall be [500 feet, or the length necessary to accommodate the amount of pipe installed in a single day, whichever is greater]. All trenches shall be fully backfilled at the end of each day or, in lieu thereof, shall be protected in accordance with Section 01 71 50 – Protection of Existing Facilities. The Contractor shall provide temporary 6-foot chain link fencing panels for protection of all open excavations and trenches within public streets, residential areas, and all other locations with the exception of unimproved open areas where excavations and/or pipeline trenches that can be safely sloped in accordance with current OSHA standards to provide safe access without the use of shoring devices. Temporary fencing panels shall fully enclose open excavations and trenches, and shall remain in place during all non-working hours.

D. Trench Overexcavation: Where trenches are indicated to be overexcavated, excavation shall be to the depth indicated, and backfill shall be installed to the grade of the bottom of the pipe bedding.

E. Overexcavation: When ordered by the Engineer, whether indicated on the Drawings or not, trenches shall be overexcavated beyond the depth and/or width shown. Such overexcavation shall be to the dimensions ordered. The trench shall then be backfilled to the grade of the bottom of the pipe bedding. Overexcavation less than 6 inches below the limits on the Drawings shall be done at no increase in cost to the Owner. When the overexcavation ordered by the Engineer is 6 inches or greater below the limits shown, or wider, additional payment will be made. Said additional payment will be made under separate unit price bid items for overexcavation if such bid items have been established; otherwise payment will be made in accordance with a negotiated price.

F. Where pipelines are to be installed in embankments, fills, or structure backfills, the fill shall be constructed to a level at least one foot above the top of the pipe before the trench is excavated.

G. If a moveable trench shield is used during excavation operations, the trench width shall be wider than the shield so that the shield is free to be lifted and then moved horizontally without binding against the trench sidewalls. If the trench walls cave in or slough, the trench shall be excavated as an open excavation with sloped sidewalls or with trench shoring, as indicated and as required by the pipe structural design.

3.4 OVEREXCAVATION NOT ORDERED OR INDICATED

A. Any overexcavation carried below the grade ordered or indicated, shall be backfilled to the required grade with the indicated material and compaction. Such work shall be performed at no additional cost to the Owner.

3.5 EXCAVATION IN LAWN AREAS

A. Where excavation occurs in lawn areas, the sod shall be carefully removed, dampened, and stockpiled to preserve it for replacement. Excavated material may be placed on the lawn; provided, that a drop cloth or other suitable method is employed to protect the lawn from damage. The lawn shall not remain covered for more than 72 hours. Immediately after completion of backfilling and testing of the pipeline, the sod shall be replaced and lightly rolled in a manner so as to restore the lawn as near as possible to its original condition. Provide new sod if stockpiled sod has not been replaced within 72 hours.

3.6 EXCAVATION IN VICINITY OF TREES

A. Except where trees are indicated to be removed, trees shall be protected from injury during construction operations. No tree roots over 2 inches in diameter shall be cut without express permission of the Engineer. Trees shall be supported during excavation by any means previously reviewed by the Engineer.

3.7 BACKFILL – GENERAL

A. Backfill shall not be dropped directly upon any structure or pipe. Backfill shall not be placed around or upon any structure until the concrete has attained sufficient strength to withstand the loads imposed. Backfill around water retaining structures shall not be placed until the structures have been tested, and the structures shall be full of water while backfill is being placed. Structures shall not be constructed on CLSM backfill until the CLSM has obtained a 7-day minimum cure.

B. Except for drainrock materials being placed in overexcavated areas or trenches, backfill shall be placed after all water is removed from the excavation, and the trench sidewalls and bottom have been dried to a moisture content suitable for compaction.

C. If a moveable trench shield is used during excavation, pipe installation, and backfill operations, the shield shall be moved by lifting the shield free of the trench bottom or backfill and then moving the shield horizontally. Do not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and backfill.

D. Immediately prior to placement of backfill materials, the bottoms and sidewalls of trenches and structure excavations shall have all loose sloughing, or caving soil and rock materials removed. All materials disturbed from their intact condition that are 4 inches or larger in least dimension or aggregates of soil material thicker than 4 inches shall be removed from the excavation walls and base prior to placing pipe or any backfill material. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of backfill materials.

3.8 PLACING AND SPREADING OF BACKFILL MATERIALS

A. Backfill materials shall be placed and spread evenly in layers. When compaction is achieved using mechanical equipment, the layers shall be evenly spread so that the depth of each uncompacted layer shall not exceed 8 inches of compacted thickness.

B. During spreading, each layer shall be thoroughly mixed as necessary to promote uniformity of material in each layer. Pipe zone backfill materials shall be manually spread around the pipe so that when compacted the pipe zone backfill will provide uniform bearing and side support.

C. Where the backfill material moisture content is below the optimum moisture content, water shall be added before or during spreading until the proper moisture content is achieved.

D. Where the backfill material moisture content is too high to permit the indicated degree of compaction the material shall be dried or mixed with drier material until the moisture content is satisfactory.

3.9 COMPACTION OF EARTH FILL, BACKFILL, AND EMBANKMENT MATERIALS

A. Each layer of Types A, B, C, G, H, I, and K backfill materials as defined herein, where the material is graded such that at least 10 percent passes a No. 4 sieve, shall be mechanically compacted to the indicated percentage of density. Equipment that is consistently capable of achieving the required degree of compaction shall be used and each layer shall be compacted over its entire area while the material is at the required moisture content.

B. Each layer of Type E and J backfill materials shall be compacted by means of at least 2 passes from a flat plate vibratory compactor. When such materials are used for pipe zone backfill, vibratory compaction shall be used at the top of the pipe zone or at vertical intervals of 24 inches, whichever is the least distance from the subgrade.

C. Fill on reservoir and structure roofs shall be deposited at least 30 days after the concrete roof slab has been placed. Equipment weighing more than 10,000 pounds when loaded shall not be used on a roof. A roller weighing not more than 8,000 pounds shall be used to compact fill on a roof.

D. Pipe zone backfill materials that are granular, shall be compacted by using vibratory compactors.

E. Equipment weighing more than 10,000 pounds shall not be used closer to structure walls than a horizontal distance equal to the depth of the fill at that time. Hand operated power

compaction equipment shall be used where use of heavier equipment is impractical or restricted due to weight limitations.

F. Backfill around and over pipelines that is mechanically compacted shall be compacted using light, hand operated, vibratory compactors and rollers. After completion of at least 2 feet of compacted backfill over the top of pipeline, compaction equipment weighing no more than 8,000 pounds may be used to complete the trench backfill.

G. Compaction Requirements: The following compaction test requirements shall be in accordance with ASTM D 1557, method C. Compaction shall be obtained with the moisture content within plus or minus 2 percent of the optimum moisture content. Where agency or utility company requirements govern, the highest compaction standards shall apply.

Location or Use of Fill	Percentage of Maximum Density
Pipe embedment backfill for flexible pipe	90
Pipe bedding and overexcavated zones under bedding for flexible pipe, including trench plugs	90
Pipe embedment backfill for steel yard piping	---
Pipe embedment backfill for rigid pipe	90
Pipe zone backfill portion above embedment for rigid pipe	90
Pipe bedding and overexcavated zones under bedding for rigid pipe	90
Final backfill, beneath paved areas or structures	95
Final backfill, not beneath paved areas or structures	85
Trench zone backfill, beneath paved	

areas and structures, including trench plugs	95
Trench zone backfill, not beneath paved areas or structures, including trench plugs	90
Embankments and fills	90
Embankments and fills beneath paved areas or structures	95
Backfill beneath structures and hydraulic structures	95
Backfill and fill around structures on reservoir or structure roof	90
Topsoil (Type K material)	80
Aggregate base or subbase (Type G or M material)	95

H.

3.10 PLACEMENT OF CLSM

A. Following placement and anchoring of the pipe, remove all loose soil from trench walls and floor. Remove any unstable soil at the top of the trench, which might fall into the trench during placement of the CLSM.

B. Prior to placement of CLSM, the pipeline steel temperature shall be controlled as specified in Section 02570 - Steel Pipe.

C. Deliver the CLSM to the trench in ready mix trucks and utilize pump or chutes to place the CLSM in the trench. Direct CLSM to one side of the pipe, taking care not to displace the pipe at any time. Continue placing CLSM on one side of the pipe until CLSM has gone under the pipe and up the other side to a depth of 1.5 feet above the pipe bottom. Use at least two hand-held vibrators to continuously liquefy and move CLSM into all voids. Adjust water in mixture

to maintain fluid consistency but maintain strength requirements. Continue placing CLSM on both sides of the pipe continuously using two vibrators for every 30 feet of pipe run.

D. Maintain stability of pipe throughout CLSM placement. CLSM will likely require placement in lifts to prevent pipe flotation. No movement of the pipe caused by flotation will be allowed. If any movement occurs, the CLSM material shall be removed and the pipe placed back on line and grade. Any damage to the pipeline system caused by movement of the pipe shall be removed and/or repaired in full conformance with these Contract Documents at no additional cost to the Owner. Remove all sloughed material or other debris from top of previously placed CLSM.

3.11 PIPE AND UTILITY TRENCH BACKFILL

A. Pipe Zone
   1. The pipe zone is defined as that portion of the vertical trench cross-section lying between a plane 6 inches below the bottom surface of the pipe and a plane at a point 12 inches above the top surface of the pipe. The bedding is defined as that portion of pipe zone backfill material between the bottom of the trench and the bottom of the pipe. The embedment is defined as that portion of the pipe zone material between the bedding and a plane at a point 6 inches above the top surface of the pipe.
   2. After compacting the bedding, perform a final trim using a string line for establishing grade, such that each pipe section when first laid will be continually in contact with the bedding along the extreme bottom of the pipe. Excavation for pipe bells and welding shall be made as required.
   3. The pipe zone shall be backfilled with the indicated backfill material. Exercise care to prevent damage to the pipeline coating, cathodic bonds, and the pipe itself during the installation and backfill operations.
   4. If a moveable trench shield is used during backfill operations the shield shall be lifted to a location above each layer of backfill material prior to compaction of the layer. Do not displace the pipe or backfill while the shield is being moved.

B. Trench Zone: After the pipe zone backfills have been placed, backfilling of the trench zone may proceed. The trench zone is defined as that portion of the vertical trench cross-section lying between a plane 12 inches above the top surface of the pipe and a plane at a point 18 inches below the finished surface grade, or if the trench is under pavement, 18 inches below the roadway subgrade.

C. Marking Tape Installation
   1. Continuously install metallic marking tape along the pipe at a depth of 3 feet below finish grade.
   2. Continuously install plastic marking tape along the pipe at the elevation indicated on the Drawings.

D. Final Backfill: Final backfill is all backfill in the trench cross-sectional area within 18 inches of finished grade, or if the trench is under pavement, all backfill within 18 inches of the roadway subgrade.

3.12 FILL AND EMBANKMENT CONSTRUCTION

A. The area where a fill or embankment is to be constructed shall be cleared of all vegetation, roots and foreign material. Following this, the surface shall be scarified to a depth of 6 inches, moisture conditioned, and rolled or otherwise mechanically compacted. Embankment and fill material shall be placed and spread evenly in approximately horizontal layers. Each layer shall be moistened or aerated, as necessary. Unless otherwise approved by the Engineer, the depth of each uncompacted layer shall not exceed 8 inches of compacted thickness. The embankment, fill, and the scarified layer of underlying ground shall be compacted to 95 percent of maximum density under structures and paved areas, and 90 percent of maximum density elsewhere.

B. When an embankment or fill is to be made and compacted against hillsides or fill slopes steeper than 5H:1V, the slopes of hillsides or fills shall be horizontally benched to key the embankment or fill to the underlying ground. A minimum of 12 inches normal to the slope of the hillside or fill shall be removed and recompacted as the embankment or fill is brought up in layers. Material thus cut shall be recompacted along with the new material at no additional cost to the Owner. Hillside or fill slopes 5H:1V or flatter shall be prepared in accordance with Paragraph A, above.

C. Where embankment or structure fills are constructed over pipelines, the first 4 feet of fill over the pipe shall be constructed using light placement and compaction equipment that does not damage the pipe.

D. The finish graded surface of the drainrock immediately beneath hydraulic structures shall be stabilized to provide a firm, smooth surface upon which to construct reinforced concrete floor slabs. Where needed to protect slopes and prevent movement of the drainrock, spray asphalt on the finished drainrock surface in accordance with Section 02460 - A. C. Pavement and Base.

3.13 FIELD TESTING

A. General: All field soils testing will be done by a testing laboratory of the Owner's choice at the Owner's expense except as indicated below.

B. Where soil material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content will be determined in accordance with Method C of ASTM D 1557. Field density in-place tests will be performed in accordance with ASTM D 1556 or by such other means acceptable to the Engineer.

C. In case the test of the fill or backfill show noncompliance with the required density, perform remedies as may be required to ensure compliance. Subsequent testing to show compliance shall be by a testing laboratory selected by the Owner, paid by the Contractor, at no additional cost to the Owner.

D. Provide test trenches and excavations including excavation, trench support, and groundwater removal for the Owner's field soils testing operations. The trenches and excavations shall be provided at the locations and to the depths required by the Owner. All Work for test trenches and excavations shall be provided at no additional cost to the Owner.

E. Frequency of Testing

1. Backfill around structures and in embankments shall be tested every 300 square ft of each lift of placement.
2. CLSM shall be tested each batch being placed or every 300 cubic yards that is placed.
3. Pipe backfill shall have one test every 80 feet (2 joints) of backfill placed.

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SECTION 31 23 19
DEWATERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes construction dewatering.

1.3 PERFORMANCE REQUIREMENTS

A. The Contractor shall provide all labor, materials, and equipment necessary to dewater site excavations, in accordance with the requirement of the Contract Documents.

B. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control ground-water flow into excavations and permit construction to proceed on dry, stable subgrades.
   1. Maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
   2. Prevent surface water from entering excavations by grading, dikes, or other means.
   3. Accomplish dewatering without damaging existing buildings adjacent to excavation.
   4. Remove dewatering system if no longer needed.

C. To complete this Work, the Contractor shall secure a Utah Pollution Elimination Discharge System (UPDES) General Permit for Construction Dewatering and Hydrostatic Testing prior to commencing any dewatering work.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with water disposal requirements of authorities having jurisdiction.

1.5 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Engineer and then only after arranging to provide temporary utility services according to requirements indicated.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for dewatering.
2. The geotechnical report is included elsewhere in the Project Manual.

C. Survey adjacent structures and improvements, employing a qualified professional engineer or land surveyor, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Engineer if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS – (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

B. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed, or until dewatering is no longer required.

C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

D. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
   1. Maintain free water level below bottom of excavation during construction.

E. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

F. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.
   1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

G. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

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SECTION 31 32 19
GEOTEXTILES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install geotextiles, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCES

A. ASTM International (ASTM) standards, most recent editions:

ASTM D 4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon-Arc Type Apparatus.
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4595	Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 4884	Standard Test Method for Strength of Sewn or Thermally Bonded Seams of Sewn Geotextiles.
ASTM D 4886	Standard Test Method for Abrasion Resistance of Geotextiles (Sand Paper/Sliding Block Method).

1.3 DEFINITIONS.

A. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

B. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile provided.

C. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile provided.

D. Nondestructive Sample: Sample representative of finished geotextile, prepared for testing without destruction of geotextile.

E. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

F. Seam Efficiency: Ratio of tensile strength across seam to strength of intact geotextile, when tested according to ASTM D 4884.

G. Woven geotextile: A geotextile fabric composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern.

H. Nonwoven geotextile: A geotextile fabric composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 20 – Contractor Submittals.

B. Product Data.
1. Manufacturer's material specifications and product literature.
2. Installation drawings showing geotextile sheet layout, location of seams, direction of overlap, and sewn seams.
3. Description of proposed method of geotextile deployment, sewing equipment, sewing methods, and provisions for holding geotextile temporarily in place until permanently secured.

C. Samples.
1. Geotextile: One-piece, minimum 18-inches long, taken across full width of roll of each type and weight of geotextile. Label each with brand name and furnish documentation of lot and roll number from which each sample was obtained.
2. Field Sewn Seam: 5-foot length of seam, 12-inches wide with seam along center, for each type and weight of geotextile.
3. Securing Pin and Washer: 1 each.

D. Certificates.
1. Certification from geotextile manufacturer that products satisfy the indicated requirements.
2. Field seam efficiency test results.

1.5 DELIVERY, STORAGE AND HANDLING

A. Comply with Section 01 25 10 - Products, Materials, Equipment and Substitutions.

B. Deliver each roll with sufficient information attached to identify manufacturer and product name or number.

C. Handle products in manner that maintains undamaged condition.

D. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in a way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

PART 2 - PRODUCTS

2.1 WOVEN GEOTEXTILE

A. Woven geotextile shall be composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester or polypropylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

C. Sheet Edges: Selvaged and finished to prevent outer material from separating from sheet.

D. Unseamed Sheet Width: Minimum 12 feet.

E. Nominal Weight per Square Yard: 6 ounces.

F. Physical Properties: Conform to physical property requirements below:

Property	Requirement	Test Method
Apparent Opening Size (AOS)	No. 10 to No. 100 U.S. Standard Sieve Size	ASTM D4751
Water Permittivity	0.02 to 3.34 $Sec.^{-1}$, MinARV	ASTM D4491 (Falling Head)
Vertical Water Flow Rate	10 to 150 gpm/sq ft, MinARV	
Wide Width Strip Tensile Strength	60 to 1,500 MinARV	ASTM D4595
Wide Width Strip Elongation	14 to 60 percent, MaxARV	ASTM D4595
Trapezoidal Tear Strength	30 to 200 lb, MinARV	ASTM D4533
Puncture Strength	50 to 250 lb, MinARV	ASTM D4833
Abrasion Resistance	5 to 25 percent loss, 250 cycles, MaxARV	ASTM D4886
Ultraviolet Radiation Resistance	70 to 90 percent strength retention, MinARV after 500 hours	ASTM D4355

2.2 NONWOVEN GEOTEXTILE

A. Nonwoven geotextile shall be composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester, polypropylene, or polyethylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

C. Geotextile Edges: Selvaged or finished to prevent outer material from separating from sheet.

D. Unseamed Sheet Width: Minimum 6 feet.

E. Nominal Weight Per Square Yard: 8 ounces.

F. Physical Properties: Conform to physical property requirements below:

Property	**Requirement**	**Test Method**
Apparent Opening Size (AOS)	Max No. 80 U.S. Standard Sieve Size	ASTM D4751
Water Permittivity	1.4 $sec.^{-1}$, MinARV	ASTM D4491 (Falling Head)
Vertical Water Flow Rate	95 gpm/sq ft, MinARV	
Grab Tensile Strength	205 MinARV	ASTM D4632
Grab Tensile Elongation	50 percent, MaxARV	ASTM D4632
Trapezoidal Tear Strength	80 lb, MinARV	ASTM D4533
CBR Puncture Strength	500 lb, MinARV	ASTM D6241
Ultraviolet Radiation Resistance	70 percent strength retention, MinARV after 500 hours	ASTM D4355

Property	**Requirement**	**Test Method**
Apparent Opening Size (AOS)	Max No. 40 U.S. Standard Sieve Size	ASTM D4751
Water Permittivity	0.70 $sec.^{-1}$, MinARV	ASTM D4491
Tensile Strength	180 lbs, MinARV	ASTM D4632
Elongation at failure (%)[1]	$\geq$50	ASTM D4632
Puncture Strength	80 lb	ASTM D4833

Property	Requirement	Test Method
Ultraviolet Radiation Resistance	70 percent strength retention, MinARV after 500 hours	ASTM D4355

1. Minimum average roll value (weakest principal direction)

2.3 SEWING THREAD

A. Sewing thread shall be polypropylene, polyester, or Kevlar thread with durability equal to or greater than durability of geotextile sewn.

2.4 SECURING PINS

A. Securing pins shall be steel rods or bars conforming to the following:
1. 3/16-inch diameter.
2. Pointed at one end; head on other end, sufficiently large to retain washer.
3. Minimum Length: 12-inches.

B. Steel Washers for Securing Pins:
1. Outside Diameter: Not less than 1-1/2 inches.
2. Inside Diameter: 1/4-inch.
3. Thickness: 1/8-inch.

C. Steel Wire Staples:
1. U-shaped.
2. 10-gauge.
3. Minimum 6-inches long.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Laying Geotextile
1. Notify the Engineer whenever geotextiles are to be placed. Do not place geotextile prior to obtaining Engineer's approval of underlying materials.
2. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

B. Orientation on Slopes
1. Orient geotextile with long dimension of each sheet parallel to direction of slope.
2. Geotextile may be oriented with long dimension of sheet transverse to direction of slope only if sheet width, without unsewn seams, is sufficient to cover entire slope and anchor trench and extend at least 18-inches beyond toe of slope.

C. Joints.
1. Unseamed Joints.
a. Overlap unseamed joints to the following dimensions unless otherwise indicated:
b. Foundation/Subgrade Stabilization: Minimum 18-inches.

c. Riprap: Minimum 18-inches.
d. Drain Trenches: Minimum 18-inches, except overlap shall equal trench width if trench width is less than 18-inches.
e. Other Applications: Minimum 12-inches.

2. Sewn Seams.
a. Use sewn seams wherever stress transfer from one geotextile sheet to another is necessary. Sewn seams, as approved by Engineer, also may be used instead of overlap at joints for applications that do not require stress transfer.
b. Seam efficiency shall be minimum 70 percent.
c. Type: "J" type seams are preferred, but flat or butterfly seams are acceptable.
d. Stitch Count: Minimum 3 to maximum 7 stitches per inch.
e. Stitch Type: Double-thread chain stitch, Type 401, Federal Standard No. 751a.
f. Stitch Location: 2-inches from geotextile sheet edges, or more if necessary to develop required seam strength.
g. Sewing Machines: Capable of penetrating 4 layers of geotextile.

D. Securing Geotextile.
1. Secure geotextile during installation as necessary with sand bags or other means approved by Engineer.
2. Securing Pins
a. Insert securing pins with washers through geotextile, midway between edges of overlaps and 6-inches from free edges.
b. Spacing:

Slope	Maximum Pin Spacing (Feet)
Steeper than 3:1	2
3:1 to 4:1	3
Flatter than 4:1	5

c. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.
d. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.
3. For underdrain applications (geotextile cushion over PVC or rubber waterproof membrane liner) do not use pins, staples or other securing methods that would damage waterproof membrane liner.

E. Placing Products over Geotextile.
1. Notify Engineer before placing material over geotextile. Do not cover installed geotextile prior to receiving authorization from the Engineer to proceed.
2. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geotextile. Repair damage as indicated below.

F. Installing Geotextile in Trenches.
1. Place geotextile in a way that will completely envelope granular drain material to be placed in trench and with indicated overlap at joints. Overlap geotextile in direction

of flow. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

2. After granular drain material is placed to grade, fold geotextile over top of granular drain material, unless otherwise indicated. Maintain overlap until overlying fill or backfill is placed.

G. Riprap Applications.

1. Overlap geotextile at each joint with upstream sheet of geotextile overlapping downstream sheet. Sew joints where wave run-up may occur.

H. Geotextile-Reinforced Earth Wall Applications.

1. Sew exposed joints; extend sewn seams minimum 3-feet behind face of wall.
2. Protect exposed geotextile from damage and deterioration until permanent facing is applied.

I. Silt Fence Applications.

1. Install geotextile in one piece or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench.
2. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.
3. Securely fasten geotextile to a wire mesh backing and each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.
4. Promptly repair or replace silt fence that becomes damaged.

3.2 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile. Repair damaged geotextile by placing patch of undamaged geotextile over damaged area plus at least 18-inches in all directions beyond damaged area. Remove interfering material as necessary to expose damaged geotextile for repair. Sew patches or secure them with pins and washers, as indicated above for securing geotextile, or by other means approved by Engineer.

3.3 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in Engineer's opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

3.4 FIELD QUALITY CONTROL

A. Testing: Test seam efficiency by preparing and testing minimum of one set of nondestructive samples per acre of each type and weight of geotextile provided for the Work. Test according to ASTM D4884 and submit written results to Engineer.

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DIVISION 32
EXTERIOR IMPROVEMENTS

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SECTION 32 12 16
A.C. PAVEMENT AND BASE

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall perform all work associated with A.C. Pavement and Base, as shown and specified herein including all labor, materials, equipment supplies and facilities associated with providing of finished product satisfying all the requirements of the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

AASHTO M 82	Cut-Back Asphalt (Medium Curing Type)
AASHTO M 140	Emulsified Asphalt
AASHTO M 208	Cationic Emulsified Asphalt
AASHTO M 226	Viscosity Graded Asphalt Cement
ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 692	Coarse Aggregate for Bituminous Paving Mixtures
ASTM D 977	Emulsified Asphalt
ASTM D 1073	Fine Aggregate for Bituminous Paving Mixtures
ASTM D 1188	Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1557	Moisture-Density Relations of Soils and Soil - Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in (45-mm) Drop7
ASTM D 2027	Cutback Asphalt (Medium Curing Type)
ASTM D 2397	Cationic Emulsified Asphalt
ASTM D 2726	Bulk Specific Gravity and Density of Compacted Bituminous Mixtures using Saturated Surface-Dry Specimens.
ASTM D 3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 3515	Hot-Mixed, Hot-Laid Bituminous Paving Mixtures.

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 20 - Contractor Submittals. Include materials testing reports, job-mix formulas, and other pertinent information satisfactory to the Engineer.

B. Prior to Delivery to Site:
   1. Mix Design: Submit current mix design dated within one year of submittal listing:
      a. Date of mix design
      b. Asphalt cement source, type and chemical composition.
      c. Aggregate gradation target.
      d. Asphalt cement target percentage, dust to asphalt ratio, moisture sensitivity (tensile strength ratio), stability, flow and voids in the bituminous mix.
   2. Before changing mix design, submit new design to Engineer 10-days prior to placing pavement for review and evaluation of changes.
   3. Type and number of compaction and finish rollers.

C. At Delivery: Supply a batch ticket identifying:
   1. Serial Number of ticket.
   2. Date and truck number.
   3. Job name, location and mix identification.
   4. Type, grade and weight of asphalt.
   5. Type, grade and weight of aggregate.
   6. Mix design method.

D. Trial Batch: Before placing any paving material, a testing laboratory acceptable to the Engineer shall prepare a trial batch of asphalt concrete for each job-mix formula to be used by the Contractor for the work. The trial batch shall be prepared using the aggregates and asphalt cement proposed by the Contractor, and approved by the Engineer. The compacted trial batch shall provide a basis for computing the voids ratio, provide an indication of the optimum asphalt content, and establish a basis for controlling compaction during construction. The cost of not more than two laboratory trial batch tests will be paid by the Owner but the Contractor shall furnish the materials at no cost to the Owner. Any additional trial batch testing required shall be performed at the expense of the Contractor.

1.4 QUALITY ASSURANCE

A. Use a laboratory that follows and complies with ASTM D 3666.

B. Do not change aggregate source, asphalt source or mix design without Engineer's prior written approval.

C. Reject product and work that does not meet the requirements of this Section.

D. Remove product that is found to be defective after installation and install acceptable product at no additional cost to the Owner.

E. Foreman of paving crew shall have completed at least five projects of similar size and nature.

1.5 WEATHER

A. Do not pave until air temperature is 45 degrees F and rising.

B. Cease paving if air temperature falls below 50 degrees F.

C. Do not pave is surface is wet or if rain, snow or other precipitation is expected.

D. Do not pave if wind or ground cools the mix material before compaction.

1.6 ACCEPETANCE

A. General: Acceptance is by lot.

B. Materials:
   1. Lot is one day's production.
   2. At the source:
      a. Aggregate: Verify gradation. Collect sample from the conveyor belt or stockpile if belt is not accessible.
      b. Paving Asphalt: Asphalt shall meet the requirements of this section and shall satisfy the limits identified in the Utah Department of Transportation's "Manual of Instructions – Part 8 Materials"
      c. Mix Temperature shall not exceed 325 degrees F in the transport vehicle.
   3. At the Site:
      a. A sub-lot is 500 tons.
      b. Obtain one random sample per sub-lot behind the paver before compaction or at locations exhibiting non-uniform appearance.
   4. At the Laboratory:
      a. Air voids shall be evaluated on the basis of laboratory compacted samples.
      b. Dust to asphalt ratio.
      c. Asphalt content and aggregate gradation.
   5. If material does not meet any requirement of the specification, the Engineer may direct that the sub-lot be removed and replace with a material meeting the specification requirements at no additional cost to the Owner.

C. Installation:
   1. Observation of Contractor's field quality control testing does not constitute acceptance.
   2. Opening a paved surface to traffic does not constitute acceptance:
   3. Reject any mixes exceeding 325 degree F in transport vehicle.
      a. Dispose of cold mix in paver hopper as thin spread underlay.
   4. Grade, Cross Slope: Verify that tolerance is not exceeded.
   5. Compaction:
      a. For compaction a lot is 1,000 square yards or any part thereof.
      b. Core Density: A lot is acceptable if the average core density does relative to ASTM D 2041 is 93 percent, with no individual test less than 89 percent.
      c. At least two test locations shall be sampled per ASTM D 3665 and three core samples shall be collected per each test location per ASTM D 5361. Core samples shall be full depth.

d. Cores shall be tested per ASTM D 2725 for core density and ASTM D 2041 (Rice) for maximum theoretical density.
e. Other non-destructive testing methods may be used during placement to aid in establishing a rolling pattern and determining the required compaction effort. However, density acceptance will be by core densities.

6. Thickness:
   a. For thickness a lot is 1,000 square yards or any part thereof.
   b. Core Thickness: A lot is acceptable if the average core thickness is not less than 0.25 inches less than the specified thickness.
   c. At least two test locations shall be sampled per ASTM D 3665 and three core samples shall be collected per each test location per ASTM D 5361. Core samples shall be full depth.
   d. Cores shall be tested per ASTM D 3549 for thickness.
7. Lots that are not acceptable may be rejected and the Engineer may direct that the lot be removed and replaced at no additional cost to the Owner.

PART 2 - PART 2 – PRODUCTS

2.1 UNTREATED BASE COURSE

A. The untreated base course shall consist of select material, either natural or crushed and shall be graded as follows:

Sieve Size	Gradation Ideal Gradation
3/4 inch	100
3/8-inch	75-95
No. 4 sieve	55-70
No. 16 sieve	30-40
No. 200 sieve	2-10

2.2 TACK COAT

A. Tack coat shall be emulsified asphalt Grade SS-1 or SS-1h, CSS-1 or CSS-1h diluted with one part water to one part emulsified asphalt, undiluted asphalt Grade RS-1 or CRS-1, or paving asphalt Grade AR-1000. Emulsified asphalt shall comply with the requirements of AASHTO M 140 (ASTM D 977) or M 208 (ASTM D 2397); paving asphalt shall comply with the requirements of AASHTO M 226 (ASTM D 3381).

2.3 ASPHALT CEMENT (AC)

A. Petroleum Asphalt that complies with table 2 of ASTM D 3381 except as follows:
   1. Replace ductility at 77 deg F. with ductility at 39.2 deg. F. Use the following values:
      a. AC - 10: greater than 15
      b. AC - 20: greater than 5
   2. Delete the loss on heating requirement on the residue from the “Thin-Film Oven Test”.

B. Substitute Performance Graded Asphalt Binder (PGAB)
   1. PGAB asphalt meeting the requirements of ASTM D 6373 may be substituted for AC asphalt cement as follows:

a. AC - 10 – PGAB 58-22 or PGAB 58-28
b. AC - 20 – PGAB 64-22

2.4 AGGREGATE

A. Aggregate shall be clean, hard, durable, angular and sound consisting of crushed stone, crushed slag, crushed gravel, sand, or a combination of two or more of these materials.

B. Source Suitability: Use the following requirements to determine the suitability of the aggregate source and not for project control.
1. Coarse Aggregates:
a. Angularity (fractured faces), ASTM D 5281: 50 percent maximum by weight of particles with at least 2 fractured faces.
b. Hardness (toughness), ASTM C 131: 40 percent minimum wear of aggregate retained above the No. 4 sieve unless specific aggregates having higher values are known to be satisfactory.
c. Flat or elongated particles, ASTM D 4791: 20 percent maximum retained above the 3/8 inch sieve has a 3:1 length to width ratio.
2. Fine Aggregates:
a. Friable Particles, ASTM C 142: 2 percent maximum passing the No. 4 sieve.
b. Plasticity, ASTM D 4318: Aggregate passing the no. 40 sieve shall be non-plastic even when filler material is added to the aggregate.
1) Liquid Limit: Less than 25
2) Plastic Limit: Less than 6

C. Combinations of aggregates having a history of polishing shall not be used in surface courses.

2.5 ADMIXTURES

A. Mineral filler shall comply with ASTM D 242.

B. Antistrip shall be heat stable cement slurry of lime slurry.

2.6 MIX DESIGN

A. Material Designation:
1. Asphalt Cement shall be AC-20.
2. Aggregate gradation shall be DM-3/4.
3. Traffic Classification shall be Heavy.

B. Design Aggregate Gradation: The job-mix formula for the asphalt-aggregate surface course mixture shall be within the following gradation limits as percent passing by weight, ASTM C 136:

Aggregate Gradations				
Sieve Size	DM-1	DM-3/4N	DM-3/4	DM-1/2
1 inch	100			
3/4 inch		100	100	
1/2 inch	75-91	74-99		100
3/8 inch		69-91	75-91	

No. 4	47-61	49-65	46-62	60-80
No. 8		33-47		
No. 16	23-33	21-35	22-34	28-42
No. 50	12-22	6-18	11-23	11-23
No. 200	3-7	2-6	3-7	3-7

1. Dry-rodded Unit weight per ASTM C 29 shall be a minimum of 75 pounds per cubic foot.
2. Weight Loss or soundness per ASTM C 88 shall be a maximum of 16 percent using sodium sulfate.
3. Clay Content or cleanliness per ASTM D 2419shall be determined by the sand equivalent value after passing through the dryer or prior to the drum mixer at the following levels:
   a. 45 percent minimum for Medium Traffic Classification
   b. 60 percent minimum for Heavy Traffic Classification.

C. Design Mixture Test Criteria: Use the Marshall volumetric mix design, AI MS-2: price and payment procedures

Mix Design Criteria			
Criteria	Traffic Classification		
	Light	Medium	Heavy
Number of Compaction Blows	35	50	75
Stability, lbs. (minimum), ASTM D 5581	750	1200	1800
Flow, in 0.01 inch units, ASTM D 5581	10-18		
Voids in Mineral Aggregate (VMA), percent min., ASTM D 3203 Nominal Maximum Particle Size 1” 3/4” 1/2” 3/8”	 13 14 15 16.5		
Voids in Bituminous Mix (percent)	3-5		
Dust to Asphalt Ratio	0.8 – 1.6		
Moisture Sensitivity, ASTM D 4867	>0.8 with freeze thaw conditioning and test specimen compacted at 6-8 percent air voids		

Notes
Traffic Classifications:
Light – Parking lots, driveways, light traffic residential streets, light traffic farm roads. (ESAL $<10^4$ per year)
Medium – Residential streets, rural farm and residential roads (Class II); Urban minor collector streets, rural minor collector roads (Class III). (10^4<ESAL<10^6 per year)
Heavy – Urban Minor arterial and light industrial streets, rural major collector and minor arterial highways (Class IV); Urban major arterial and heavy industrial streets, freeways, expressways, arterial highways, rural interstate, and other principal arterial highways (Class V). (ESAL > 10^6 per year)

2.7 SOURCE QUALITY CONTROL

A. General: Supplier shall randomly collect samples per ASTM D 3665. The same sample point shall be used for all samples of a particular material.
   1. Aggregate sampling shall be per ASTM D 75.
   2. Asphalt Cement sampling shall be per ASTM D 140.

B. Asphalt-aggregate mix shall be sampled per ASTM D 979 and test for:
   1. Air Voids per ASTM D 3203.
   2. Paving Asphalt Content per ASTM D 6307.
   3. Aggregate Gradation per ASTOM D 5444
   4. Tensile strength of bitumen-aggregate mixtures per ASTM D 4867.

C. Mixing plant shall meet the requirements of ASTM D 3515.

2.8 PAVEMENT MARKING PAINT

A. Pavement marking paint shall be a product specifically formulated for use on asphalt concrete pavement and shall have a proven record of performance and durability. The paint striping materials shall conform with the State of Utah Standard Specifications for Road and Bridge Construction and its addenda.

PART 3 - EXECUTION

3.1 SUBGRADE PREPARATION

A. The subgrade shall be prepared in accordance with Section 31 23 00 – Earthwork as applicable to roadways and embankments. The surface of the subgrade after compaction shall be hard, uniform, smooth and true to grade and cross-section. Subgrade for pavement shall not vary more than 0.02-foot from the indicated grade and cross section. Subgrade for base material shall not vary more than 0.04-foot from the specified grade and cross section.

3.2 UNTREATED BASE COURSE

A. Untreated base course shall be provided where shown and to the thickness indicated. Imported untreated base course shall be delivered to the job site as uniform mixtures and each layer shall be spread in one operation. Segregation shall be avoided and the base shall be free of pockets of coarse or fine material. Where the required thickness is 6 inches or less, the base materials may be spread and compacted in one layer. Where the required thickness is more than 6 inches; the base material shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 6 inches. The relative compaction of each layer of aggregate base shall be not less than 96 percent of maximum density when measured in accordance with ASTM D 1557 with no test below 92 percent of maximum density. The compacted surface of the finished aggregate shall be hard, uniform, smooth and at any point shall not vary more than 0.02 foot from the specified grade or cross-section.

3.3 TACK COAT

A. A tack coat shall be applied to existing paved surfaces where new asphalt concrete is to be placed on existing pavement. It shall also be applied to the contact surfaces of all cold pavement joints, curbs, gutters, manholes and the like immediately before the adjoining asphalt pavement is placed. Care shall be taken to prevent the application of tack coat material to surfaces that will not be in contact with the new asphalt concrete pavement. Diluted emulsified asphalt shall be applied at the rate of 0.05 to 0.15 gal/sq yd. Undiluted emulsified asphalt shall be applied at the rate of 0.025 to 0.075 gal/sq yd. Paving asphalt shall be applied at the rate of approximately 0.05 gal/sq yd.

3.4 CONSTRUCTION EQUIPMENT

A. Lay Down Machine shall have tracks when operating on fabrics, geogrids or pavement mats hotter than 180 degrees F.

B. Compactors shall be static or vibratory, steel wheel rollers. Pneumatic tire rollers may be used for intermediate rolling only.

3.5 ASPHALT CONCRETE

A. At the time of delivery to the work site, the temperature of mixture shall not be higher than 320 degrees F, and shall not be less than indicated below:

Minimum Asphalt Concrete Temperature, degrees F						
Air	Compacted Mat Thickness					
Temperature	3/4 inch	1 inch	1-1/2 inch	2 inch	3 inch	4 inch +
45-50	-	-	-	-	280	265
50-59	-	-	-	280	270	255
60-69	-	-	285	275	265	250
70-79	285	285	280	270	265	250
80-89	280	275	270	265	260	250
90+	275	270	265	260	250	250

B. The asphalt concrete shall be evenly spread upon the subgrade or base to such a depth that, after rolling, it will be of the required cross section and grade of the course being constructed.

C. The depositing, distributing, and spreading of the asphalt concrete shall be accomplished in a single, continuous operation by means of a self-propelled mechanical spreading and finishing machine designed especially for that purpose. The machine shall be equipped with a screed or strike-off assembly capable of being accurately regulated and adjusted to distribute a layer of the material to a definite pre-determined thickness. When paving is of a size or in a location that use of a self-propelled machine is impractical, the Engineer may waive the self-propelled requirement.

D. Spreading, once commenced, shall be continued without interruption.

E. The mix shall be compacted immediately after placing. If needed, intermediate rolling with a pneumatic-tired roller shall be done immediately behind the initial rolling. Final rolling shall

eliminate marks from previous rolling. In areas too small for the roller, a vibrating plate compactor or a hand tamper shall be used to achieve thorough compaction.

F. Compaction shall be completed before temperature drop to 180 degrees F.

G. Do not leave unsafe butt joints if paving operations stop.

H. Barricade or eliminate fall off edges.

I. Joints
   1. Construct joints to have the same texture, density and smoothness as other section of the new pavement course.
   2. Clean contact surfaces and apply tack coat. Ensure continuous bond between old and new pavement or between successive day's work.
   3. Offset longitudinally joints a minimum of 12 inches in succeeding courses and offset transverse joints a minimum of 6 feet to avoid a vertical joint through more than one course. In the tops course restrict longitudinal joints to either side of the lane lines.
   4. Prevent traffic, including construction traffic, from crossing vertical edges. Apply tack coat to vertical edges prior to making another pass with the paver if the mix has cooled to 90 degrees F.

3.6 TOLERANCES

A. Lift thickness shall not be less than 2 times the maximum aggregate size nor more than 3 inches (compacted thickness) or the limits established by the pneumatic or vibratory compactor equipment manufacturer, whichever is less.

B. Upon completion the pavement shall be true to grade and cross-section. When a 10-ft straightedge is laid on the finished surface parallel to the center of the roadway, the surface shall not vary from the edge of the straightedge more than 1/8-in except at intersections or changes of grade. In the transverse direction, the surface shall not vary from the edge of the straightedge more than 1/4-in.

3.7 BITUMINOUS SURFACE PATCHING

A. Where pits are excavated through bituminous surfaced roads, driveways, parking areas, etc., the surface shall be restored and maintained as follows:
   1. A temporary gravel surface shall be placed and maintained after the required backfill and compaction of the trench has been accomplished.
   2. The gravel shall be placed to such depth as to provide six inches below the pavement and shall be brought flush with the paved surface.
   3. The area over trenches to be resurfaced shall be graded and rolled with a roller weighing not less than twelve tons, or with the rear wheels of a five-yard truck loaded to capacity, until the subgrade is firm and unyielding. Mud or other soft or spongy material shall be removed and the void filled with gravel and rolled and tamped thoroughly in layers not exceeding six inches in thickness. The edges of trenches which are broken down during the making of subgrade shall be removed and trimmed neatly before resurfacing.

4. Before any permanent resurfacing is placed, the Contractor shall trim the existing paving to clean, straight lines as nearly parallel to the centerline of the trench as practicable.
5. Existing bituminous paving shall be cut back a minimum of six inches beyond the limits of any excavation of cave-in along the trench so that the edges of the new paving will rest on at least six inches of undisturbed soil.
6. As soon as is practical, weather permitting, the bituminous surface shall be restored by standard paving practices to the thickness specified herein.
7. Pavement restoration shall include tacking of pavement of edges and subbase with MC 70-250 bituminous material and placing rolling plant hot mix bituminous material to the level of the adjacent pavement surfaces.

3.8 PROTECTION AND REPAIR

A. General: All work is at no additional expense to the Owner.

B. Protection:
1. Protect all structures, including curb, gutter, sidewalks, street fixtures, delineators, signs, guard rails and guide posts.
2. Remove all spatter, over-coat or mar.
3. Do not discharge bituminous materials into borrow pits, roadside ditches, gutters or other areas.
4. Protect hot pavement from traffic until mixture has cooled enough not to become marked.
5. Protect neighborhood, storm drains and downstream wetland and fish habitats.

C. Repair
1. When thickness is deficient, place additional material over deficient areas. Do not skin patch. If necessary, mill for inlay.
2. Repair defective seams, edges and joints.
3. Remove and replace unacceptable paving.

3.9 PAVEMENT MARKING

A. Pavement marking paint shall be applied where indicated only when the pavement surface is dry and clean, and when the air temperature is above 40 degrees F. Pavement marking shall commence no sooner than 21 days after completion of pavement installation. All equipment used in the application of pavement marking shall produce stripes and markings of uniform quality with clean and well-defined edges that conform to the details and dimensions shown. Drips, overspray, improper markings, and paint material tracked by traffic shall be immediately removed from the pavement surface by methods previously reviewed by the Engineer.

END OF SECTION

SECTION 32 13 73
PAVEMENT JOINT SEALANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes joint sealants for exterior site concrete pavement work including parking lots, driveways, sidewalks, curbs, curb and gutters, waterways, etc:
   1. Joint Void-former
   2. Cold-applied joint sealants.
   3. Hot-applied joint sealants.

B. Related Sections:
   1. Division 2 Section 32 12 16 - "Asphalt Cement Pavement and Base" for constructing joints between concrete and asphalt pavement.
   2. Division 7 Section 07 92 13 - "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.

1.3 SUBMITTALS

A. Product Data: Provide Manufactures product data and sample for each joint-sealant product indicated.

B. Product Certificates: For each type of joint sealant and accessory, from manufacturer.

C. Manufacturer's instructions for joint preparation, type of cleaning and installation for each type of joint sealant.

1.4 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
   1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
   2. When joint substrates are wet.
   3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
   4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.5 SYSTEM PERFORMANCE

A. Pavement joints include longitudinal and transverse expansion joints, isolation joints, contraction joints, and crack control joints.

B. Provide joint sealants that maintain watertight and airtight continuous seals.

1.6 QUALITY ASSURANCE

A. Installation of joint systems shall follow manufacturer's published instructions.

B. For cold applied joint sealant installation, use installers that are approved by the joint sealant supplier. Provide written proof on sealant supplier's approval.

C. Obtain joint sealing materials from a single manufacturer for each different product required.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site in original, unopened containers or bundles with labels identifying manufacturer, product name and designation, color, expiration period for use, pot life, cure time, and mixing instructions for multi-component materials.

B. Store and handle materials in compliance with manufacturer's recommendations to prevent deterioration; or damage due to moisture, high or low temperatures, contaminants or other causes.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.

2.2 JOINT VOID-FORMER

A. Plastic, with a water stop.

B. ¼ depth of concrete slab thickness.

2.3 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant for Concrete: ASTM D 5893, Type NS.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Crafco Inc., an ERGON company; RoadSaver Silicone.
      b. Dow Corning Corporation; 888.
      c. Pecora Corporation; 301 NS.

B. Single-Component, Self-Leveling, Silicone Joint Sealant for Concrete: ASTM D 5893, Type SL.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Crafco Inc., an ERGON company; RoadSaver Silicone SL.

b. Dow Corning Corporation; 890-SL.
c. Pecora Corporation; 300 SL.

C. Single-Component, Self-Leveling, Polyurethane Joint Sealant for Concrete: ASTM D 5893, Type SL.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Sikaflex – 1C SL - Polyurethane SL.

D. Multicomponent, Pourable, Traffic-Grade, Urethane Joint Sealant for Concrete: ASTM C 920, Type M, Grade P, Class 25, for Use T.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Pecora Corporation; Urexpan NR-200.

2.4 HOT-APPLIED JOINT SEALANTS

A. Hot-Applied, Single-Component Joint Sealant for Concrete: ASTM D 3406.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Crafco Inc., an ERGON company; Superseal 444/777.

B. Hot-Applied, Single-Component Joint Sealant for Concrete and Asphalt: ASTM D 6690, Types I, II, and III.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Meadows, W. R., Inc.; Sealtight 3405.
b. Right Pointe; D-3405 Hot Applied Sealant.

2.5 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.

B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

C. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.6 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.

B. Immediately after sawcutting control joints, wash freshly sawed joints with a high pressure wash to remove saw slurry from the joint faces.

C. Immediately prior to installing joint sealant, remove oil, grease, wax, form-release agents, curing compounds, bitumens, laitance and old chalking material by sandblast, as recommended by manufacturer of sealant. Maximum sand blast angle, 25 degrees plus or minus 5 degrees. Complete two full passes for each joint to be sealed, one blast for each face.

D. Clean and dry with air blast. Do not contaminate air blast with oils or lubricants.

E. Remove frost and moisture in concrete joint substrates before commencing sealing.

F. Install bond breaker tape where needed or required by manufacturer’s recommendations to ensure that elastomeric sealants will perform properly.

G. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Depths: Saw cut joints if necessary to provide the required sealant thicknesses and depth. Install sealant to the depths indicated or, if not indicated, as recommended by the sealant manufacturer, but within the following general limitations measured at center (thin) section of bead:

1. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to a depth

equal to 75 percent of joint width, but not more than 5/8 inch deep nor less than 3/8 inch deep.

2. For normal moving joints sealed with elastomeric sealants but not subject to traffic, fill joints to a depth equal to 50 percent of joint width, but not more than ½ inch deep nor less than ¼ inch deep.
3. For joints sealed with non-elastomeric sealants and caulking compounds, fill joints full depth.

D. Install joint-sealant backings of kind indicated to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
1. Do not leave gaps between ends of joint-sealant backings.
2. Do not stretch, twist, puncture, or tear joint-sealant backings.
3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

E. Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:
1. Place joint sealants so they directly contact and fully wet joint substrates.
2. Install joint sealants in uniform, continuous ribbons without gaps or air pockets, with complete bonding of joint surfaces on opposite sides.
3. Completely fill recesses in each joint configuration, unless otherwise indicated.
4. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
5. Where horizontal joints are between a horizontal surface and vertical surface, fill joint to form a slight cove so that joint will not trap moisture and dirt.

F. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
1. Remove excess joint sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

G. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

H. Spillage: Do not allow poured sealant compound to overflow or spill onto adjoining surfaces or to migrate into voids of adjoining surfaces. Clean adjoining surfaces to eliminate evidence of spillage.

I. Heating: Do not use overheated hot-applied sealants.

J. Edges: Unless indicated otherwise, recess exposed edges of gasket and exposed joint filler slightly behind adjoining surfaces so compressed units will not protrude from joints.

3.4 CURING AND CLEANING

A. Cure joint sealant compounds per manufacturer's instructions and recommendations to obtain high early bond strength, internal cohesive strength, and surface durability.

B. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.5 PROTECTION

A. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

3.6 PAVEMENT-JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Joints within cement concrete pavement.
   1. Joint Location:
      a. Expansion and isolation joints in cast-in-place concrete pavement.
      b. Contraction joints in cast-in-place concrete slabs.
      c. Other joints as indicated.
   2. Silicone Joint Sealant for Concrete: Single component, nonsag or Single component, self-leveling.
   3. Urethane Joint Sealant for Concrete: Multicomponent, pourable, traffic-grade.
   4. Hot-Applied Joint Sealant for Concrete: Single component.
   5. Joint-Sealant Color: Color shall match the color of adjacent concrete surfaces

B. Joint-Sealant Application: Joints between cement concrete and asphalt pavement.
   1. Joint Location:
      a. Joints between concrete and asphalt pavement.
      b. Joints between concrete curbs and asphalt pavement.
      c. Other joints as indicated.
   2. Hot-Applied Joint Sealant for Concrete and Asphalt: Single component.

END OF SECTION

SECTION 32 16 00
DRIVEWAYS, SIDEWALKS, CURBS, GUTTERS, AND OTHER CONCRETE FLATWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes exterior cement concrete flatwork such as but not limited to the following:
   1. Driveways.
   2. Curbs, gutters and waterways
   3. Sidewalks and Walkways.
   4. Other exterior site concrete flatwork.

B. Related Sections include the following:
   1. Division 2 Section 31 23 00 – Earthwork for subgrade preparation, grading, and base course.
   2. Division 2 Section 32 13 73 – Pavement Joint Sealants for joint sealants of joints in concrete flatwork and at isolation joints of concrete flatwork with adjacent construction.
   3. Division 3 Section 03 30 00 – Cast-in-Place Concrete for general building applications of concrete.

1.3 REFERENCES

AASHTO M 6	Standard Specification for Fine Aggregate for Portland Cement Concrete
AASHTO M 154	Standard Specification for Air-Entraining Admixtures for Concrete
AASHTO M 80	Standard Specification for Coarse Aggregate for Portland cement Concrete
AASHTO M 182	Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats
ACI 117	Standard Tolerances for Concrete Construction and Materials
ACI 301	Specifications for Structural Concrete for Buildings; American Concrete Institute International; 1996.
ACI 305 R	Hot Weather Concreting; American Concrete Institute International; 1991.

ACI 306 R	Cold Weather Concreting; American Concrete Institute International; 1988.
ACI CP-1(08)	Technical Workbook for ACI Certification of Concrete Field Testing Technician-Grade
ASTM A 307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
ASTM A 615/A 615M	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement; 1996a.
ASTM C 31/C31 M	Standard Practice for Making and Curing Concrete Test Specimens in the Field.
ASTM C 33	Standard Specification for Concrete Aggregates; 1993.
ASTM C 39/C39 M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens; 1996.
ASTM C 94/C94M	Standard Specification for Ready-Mixed Concrete; 1996.
ASTM C 143	Standard Test Method for Slump of Hydraulic Cement Concrete
ASTM C 150	Standard Specification for Portland Cement; 1996.
ASTM C 171	Standard Specification for Sheet Materials for Curing Concrete; 1997.
ASTM C 172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method; 1994a.
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete; 1995.
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete.
ASTM C 618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete; 1996a.
ASTM C 881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete; 1990.
ASTM C 1017/C 1017M	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete

ASTM C 1059/C1059 M	Standard Specification for Latex Agents for Bonding Fresh To Hardened Concrete
ASTM C 1064	Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete.
ASTM C 1077	Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM D 1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types); 1983 (reapproved 1991).
ASTM D 1752	Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM E 329	Standard Specification for Agencies Engaged in Construction Inspection and/or Testing
FS TT-P-1952	Pavement Markings

1.4 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with fly ash.

1.5 SUBMITTALS

A. Design Mixtures: For each concrete flatwork mixture satisfying the requirements of this section and Section 03 30 00 Cast-in-place Concrete. Include alternate mixture designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments
   1. Mix designs will be approved based on results of trial batches or on past history of mix design successes from project(s) within the last year.
   2. Use the same components in the trial batches that are to be used in the project. The Contractor assumes responsibility for the compatibility of all admixtures with the mix design and their potential effects on concrete properties.
   3. Personnel performing and witnessing trial batches, and performing compressive and flexural strength testing, must be performed by an AASHTO accredited laboratory paid for by Contractor.
   4. The Owner or Engineer may witness trial batch preparation and testing.

B. Product Data: For each type of manufactured material and product indicated.

C. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:

1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
2. For any proposed mix design, provide test results for potential reactivity of coarse and fine aggregates in accordance with the requirements of this section.
3. When using potentially reactive aggregates in a mix design, provide results from appropriate testing to determine the ability of the combinations of cementitious materials and aggregates to control the reactivity

D. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:
1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.

E. Joint Layout Plan: Submit plan showing location and type of each joint to be placed in the concrete flatwork.

F. Proof of finishers' ACI Certifications

G. Manufactures recommended installation procedures for joint sealing material which, when accepted by Engineer, will become the basis for accepting or rejecting the actual installation procedures used in the Work.

H. Delivery tickets per Section 03 30 00 – Cast-in-place Concrete

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1(08) or an equivalent certification program.

C. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.

D. Concrete Testing Service: All concrete testing will be done by a testing laboratory of the Owner's choice at the Owner's expense.

E. Do not change concrete Supplier until Engineer accepts new source and new mix design.

F. Remove product found defective after installation and install acceptable product at no additional cost to Owner.

G. Foreman of paving crew shall have completed at least three (3) projects of similar size and nature.

1.7 ACCEPTANCE

A. General: Acceptance is by lot. Lot size is specified below for each component.

B. Concrete Mix:
1. Lot size is 50 cu. yd. or fraction thereof of each concrete mix placed each day.
2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
5. For slump, air and temperature reject non-complying batches until 2 consecutive batches are compliant then continue in random batch testing for acceptance.

C. Strength
1. Lot size is 50 cu. yd. or fraction thereof of each concrete mix placed each day.
   a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
2. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of five standard cylinder specimens for each composite sample.
3. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.
4. Strength of each lot will be satisfactory if the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
5. Remaining cylinders shall be held to verify test results, if required.

D. Installation:
1. Grades, finishes, cross-slopes and dimensions of completed pavement shall be checked for compliance with plan requirements. Standing water in curb and gutter or “bird baths” in flatwork are not permitted and shall be immediately corrected by removal of failed areas and replacement per these specifications and directions of the Engineer at no additional cost to the owner.

E. Test Results: Test results shall be reported in writing to Engineer, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design

compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

F. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Engineer but will not be used as sole basis for approval or rejection of concrete.

G. Additional Tests: Engineer may direct testing and inspecting agency to make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met.

H. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

I. Additional testing and inspecting, at Contractor's expense will be performed to determine compliance of replaced or additional work with specified requirements.

1.8 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Weather: Concrete placement shall conform to the requirements of ACI 305 R and ACI 306 R for hot and cold weather, respectively in addition to the requirements of Section 03 30 00 – Cast-in-place Concrete.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
   2. Products: Subject to compliance with requirements, provide one of the products specified.
   3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
   4. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
   1. Use flexible or curved forms for curves with a radius 100 feet or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed, epoxy coated

2.4 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source throughout the Project:
   1. Portland Cement: ASTM C 150, Type II.
   2. Do not use cement that contains lumps or is partially set.
   3. Do not mix cements originating from different sources.
   4. Do not use air-entrained cement.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S coarse aggregate, uniformly graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar concrete flatwork applications and service conditions using similar aggregates and cementitious materials.
   1. Maximum Coarse-Aggregate Size: 3/4 inch nominal
   2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Mixing Water:
   1. For standard Type II Cement: ASTM C 94/C 94M

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz. /sq. yd. dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete. Evaporation Retarder shall not be used as a finishing aid.

2.6 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork.

2.7 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.
   1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.

B. Proportion mixtures to provide normal-weight concrete with the following properties:
   1. Compressive Strength (28 Days): 4000 psi.
   2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.44.
   3. Do not exceed water/cementitious ratio.
   4. Calculate the water/cementitious ratio (w/c) according to the following formula:
      a. W = Water
      b. C Cement + Pozzolan
   5. Concrete Slump Limits:
      a. For concrete not containing water reducers, 4 inches, plus or minus 1 inch.
      b. For concrete containing low range water reducers: 1 inch to 5 inches for all classes of concrete.
      c. For concrete containing high range water reducers: 4 inches to 9 inches for all classes of concrete.
   6. Cement Content: 6.5 bags

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete having an air content as follows:
   1. Air Content: 6 percent plus or minus 1.0 percent for 3/4-inch nominal maximum aggregate size at point of placement.
   2. The range listed represents air content at point of placement. Make necessary adjustments for impacts to air content due method of placement.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements for concrete exposed to deicing chemicals:

2.8 POZZOLAN

A. Fly Ash:

1. Fly ash must conform to ASTM C 618 Class F specifications with the following modifications:
    a. Loss on Ignition (LOI): not to exceed 3 percent.
    b. Maximum allowable CaO content: not to exceed 15 percent.
    c. Label the storage silo for fly ash to distinguish it from cement.
    d. Use different size unloading hoses and fittings for cement and fly ash.
    e. When used as partial portland cement replacement, the fly ash may replace 20% of the cement by weight.
2. Fly ash may be sampled and tested for compliance at any time.

2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
    1. When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 CONSTRUCTION EQUIPMENT

A. When automatic machine placement is used for placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce sidewalks, curbs, curbs and gutters, and other flatwork to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.
    1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of paver machine during operations.

3.2 EXAMINATION

A. Examine exposed subgrades and base surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proceed with concrete flatwork operations only after nonconforming conditions have been corrected and subgrade and base is ready to receive flatwork.

3.3 PREPARATION

A. Assure the subgrade or base for the concrete has a firm even surface and is compacted meeting the requirements of Section 31 23 00 – Earthwork.

B. Remove loose material from compacted base surface immediately before placing concrete.

C. Remove sand, leaves, trash, rubbish, topsoil, and other objectionable materials prior to placing concrete.

D. Coat the surface of street fixtures with oil to prevent bond with concrete flatwork.

E. Notify Engineer a minimum of 48 hours prior to commencing laying operations.

3.4 LAYOUT

A. Curb, Gutter, Curb and Gutter, Waterways: Set lines, forms, screeds, etc to meet the following requirements:
   1. Line: Less than ½ inch variance in 10 feet and not more than 1 inch from true line at any location.
   2. Grade: Not more than ¼ inch variance in 10 feet. Flood curb and gutter and waterway with water after final cure has been reached. Remove and replace any area where ponding is found.

B. Sidewalk and Walkways: Set forms, screeds, etc to meet the following requirements:
   1. Cross-slope shall not be less than 1.5% nor more than 2%.
   2. Landings and doorway aprons shall not slope more than 2% in any direction.

C. Layout shall meet the requirements as given in the construction plans.

3.5 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for flatwork to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Check formwork for grade and alignment variance from the following tolerances:
   1. Top of forms shall not be more than ¼ inch from design grade
   2. Vertical face on longitudinal axis shall not be more than ¼-inch from true line.

C. Place joint filler in vertical position, in straight lines and secure to formwork during concrete placement.

D. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.6 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete formwork installation, grade lines, steel reinforcement, and items to be embedded or cast in. Notify other trades to permit installation of their work. Inspect formwork for line and grade and make corrections as required.

B. Remove snow, ice, or frost from base surface before placing concrete. Do not place concrete on frozen surfaces.

C. Obtain Engineer's review of base, forms, lines, etc. before placing concrete. Engineer's review does not relieve the Contractor's responsibility to ensure all Work is in compliance with the contract documents and these requirements and correct defective Work as required.

D. At the beginning of concrete placement, test slump, temperature and air entrainment. If corrections are necessary, placement may proceed after 2 subsequent and consecutive batches pass testing.

E. Moisten base to provide a uniform dampened condition, without standing water, at time concrete is placed.

F. Do not place concrete around manholes or other structures until they are at required finish elevation, cross-slope and alignment.

G. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

H. Do not add water to concrete during delivery to the Project site.

I. Water may not be added to the delivery truck at the project site prior to discharge unless approved by the Engineer. If water is added at the project site, record quantity of water added on delivery ticket.

J. Site-added air-entrainment. (Meet AASHTO M 154)
   1. Limit the use of site-added air-entraining agents to one addition (regardless of quantity) per load
   2. Use pre-measured admixtures.
   3. Record amount used on batch ticket.
   4. Rotate the drum at least 30 revolutions at the mixing speed recommended by the manufacturer.

K. Do not add water to fresh concrete after testing.

L. Deposit and spread concrete in a continuous operation. Prevent segregation of concrete mix. If placement operations are interrupted for more than 30 minutes, place a construction joint.

M. Place concrete so time between end of placement and beginning of finishing is less than 15 minutes.

N. Consolidate concrete with vibrator or other acceptable method. Do not use mechanical vibrators. Prevent dislocation of inserts.

O. Cold-Weather Placement: Comply with ACI 306.R and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
   1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
   2. Do not use frozen materials or materials containing ice or snow.
   3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mix designs.

P. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.7 JOINTS

A. General:
1. Review joint layout plan with Engineer.

B. Isolation/Expansion Joints:
1. Geometrics: ½ inch wide full depth filler that is flush with concrete surface. Do not place seal over top of filler.
2. Sidewalks, Walkways, Sidewalk Ramps:
   a. Place isolation joints to separate sidewalk from utility poles, hydrants, manhole frames, buildings, abutting sidewalks and other street fixtures or structures.
   b. Place isolation joints between the sidewalk and the back of curb returns and between the sidewalk and sidewalk ramps.
   c. Do not place isolation joints in sidewalk ramp surfaces.
3. Curb, Gutter, Curb and Gutter, Waterway:
   a. Do not place longitudinal joints in gutter flow-lines.
   b. Where gutter transitions extend beyond the curb return, place expansion joints at the ends of the gutters transition.
   c. Place isolation joints at beginning of curb radius and end of curb radius.
4. Slip Form Work: Expansion joints are not required except at beginning of curb radius, end of curb radius, structures, street fixtures, inserts, foundations and other structures.
5. Driveway approach: Do not place isolation joints in curb returns.

C. Contraction Joints: Contraction joints (crack control joints) are scorelines made to force crack joint location in concrete. Form weakened-plane contraction joints, sectioning concrete into areas as indicated.
1. Geometrics:
   a. Tooled Joints (score lines)
   b. Construct contraction joints to a depth equal to at least one-fourth ($1/4^{th}$) of the concrete thickness
   c. Top radius of joints shall be ½ inch.
   d. Saw Cut Joints: Saw joints before uncontrolled shrinkage cracking occurs. Do not tear or ravel concrete during sawing.
   e. Template Joints: 1/8 to 3/16 inch wide, ¼ depth of concrete.
2. Sidewalks.
   a. Place contraction joints at intervals equal to the width of the sidewalk and transverse to the direction of travel.
   b. Place radial contraction joints curves and curb returns.

c. Place longitudinal contraction joints in walks when width of walk in feet is greater the 2 times the walk thickness in inches. (e.g. maximum width of a 4 inch thick walk before placement of a longitudinal contraction joint is 8 feet.) Make longitudinal joints parallel to, or concentric with, the lines of the walk.

d. In walk returns make one joint radially midway between the beginning of curb return and end of curb return. Match the longitudinal and transverse joints with adjacent walks.

3. Curb, Gutter, Curb and Gutter, Waterway.
   a. Place joints at intervals not exceeding 12 feet.
   b. At curb radius and walk return make the joints radial.
   c. Where integral curb and gutter is adjacent to concrete pavement, align the joints with the pavement joints, where practical.

4. Other Flatwork:
   a. Joint Spacing, in feet, shall be twice the slab thickness measured in inches, unless otherwise indicated. (i.e. Slab thickness is 6-inches, joint spacing shall be 12-feet.) Joint spacing shall not exceed 15 feet.
   b. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
   c. Keep a minimum of three (3) working power saws on site when concrete operations are underway.
   d. Longitudinal joint spacing shall match the transverse joint spacing.
   e. Transverse joints shall extend across the width of the pavement and meet the joints of the adjoining concrete surfaces (i.e. sidewalk, curb and gutter, etc.).

D. Volunteer Crack Joints: If a volunteer crack joint occurs within any flatwork of this section, sawcut and remove cracked section at nearest contraction joints and replace the section at no additional cost to the owner.

3.8 FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/2-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

C. Apply broom finish longitudinal to curb, gutter, curb and gutter, and waterway flowline.

D. Apply broom finish transverse to sidewalk, walkway and other flatwork centerline as follows:
   1. Fine hair finish where grades are less than 6 percent.
   2. Rough hair finish where grades exceed 6 percent.

E. Remove form marks, tool marks, and other irregularities from finish surfaces.

3.9 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306 R for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
   1. Curing Compound: Use a Type ID, Class A (clear with fugitive dye) membrane forming compound. Apply total coverage in 2 directions after texturing. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
   2. Eliminate thermal shock of concrete by keeping cure temperatures even throughout extent and depth on concrete slab.

3.10 REPAIRS AND PROTECTION

A. Protect concrete in compliance with requirements of Section 03 30 00 – Cast-In-Place Concrete. Remove and replace concrete flatwork that is broken, damaged, or defective or that does not comply with requirements in this Section.

B. Protect concrete from damage. Do not allow steel wheel rollers or steel wheel vehicles on the concrete flatwork.

C. Exclude traffic from concrete flatwork for at least 14 days after placement or until 100 percent of the design strength has been achieved as demonstrated by concrete cylinder compression tests.

D. If construction traffic is permitted, maintain concrete flatwork as clean as possible by removing surface stains and spillage of materials as they occur.

E. Protect fresh concrete from vandals, damage, pedestrian traffic, etc. Repair damaged section immediately to the satisfaction of the Engineer.

F. Remove saw-cut dust immediately. Do not allow saw-cut dust to be flushed down storm drains or into adjacent wetlands or landscaping areas.

G. Maintain concrete flatwork free of stains, discoloration, dirt, and other foreign material. Sweep concrete flatwork not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

SECTION 32 80 00
LANDSCAPE IRRIGATION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY OF PROJECT

A. Work to be done on Project shall:

1. Include all labor, materials, equipment, tools and transportation.
2. Perform all operations, in connection with and reasonably incidental to; the complete installation of the irrigation system.
3. Follow direction is shown on the plan sheets, legend, notes, details, specifications (the Construction Documents, hereafter referred to as CD's).

B. Items of work specifically included are:

1. Procurement of all applicable licenses and permits.
2. Payment of any fees for connection to water source and power source.
3. Coordination of location of underground utilities, by contacting local services: 'Blue Stakes' or 'Call Before You Dig'.
4. Sleeving necessary for irrigation pipe and wire.
5. Provision for and connection of the electrical power supply to the irrigation control system.
6. One-year warranty of all irrigation components and all labor required to install.
7. 90-day maintenance period of irrigation system and components.

C. All disturbed areas shall receive irrigation unless specifically indicated on CD's.

D. Revise, repair, and/or restore existing irrigation system to continue operation of existing components and to accommodate new construction. All plant material on the Project shall be irrigated unless specifically indicated on CD's.

E. Contractor shall note that location or routing of irrigation components on CD's is approximate. Piping, sleeving and/or other components may be shown schematically on CD's for graphic clarity and to demonstrate component groupings and separations. All irrigation components shall be placed in landscaped areas, except for pipe and wire in sleeving under hardscaped areas.

1.2 DEFINITIONS

A. Construction Documents: All documents provided to Contractor for proper installation of irrigation system; including plan sheets, legend, notes, details, specifications and supplemental plan issues or addenda. Referred to in this section by the acronym CD's.

B. Contract: For the purposes of the irrigation section of the specification, (Section 32 80 00) this term refers to the Contract, Sub-Contract, or portion of the Contract dealing only with the irrigation system.

C. Contractor: For the purposes of the irrigation section of the specification this term refers to the specific contractor or sub-contractor responsible for installation of the irrigation system for this project.

D. GPM: Acronym for Gallons per Minute.

E. Isolation Valve: A manual valve located on the main line that when shut off, will remove constant pressure to a specific section of the main line and corresponding downstream irrigation components.

F. Line Valve: A manual valve located on the main line that when shut off, restricts flow in the main line. More than one line valve must be shut off to isolate a section of main line and corresponding downstream irrigation components.

G. Lateral Line Piping: Circuit piping downstream of remote-control valve (RCV) providing water to sprinkler heads, bubblers, or drip components. Under pressure only when RCV activated and opened.

H. Line Voltage Wiring: Wiring used to convey power to electrically operated equipment on the Project, such as 120 VAC, 240 VAC, or 480 3PH VAC.

I. Low Voltage Wiring: Wiring used to convey power to irrigation system components, such as RCV's, master valve, flow meter, decoders, etc. An example would be: 14 AWG PE UL RCV control wire.

J. Main Line Piping: Piping downstream of Point of Connection (POC). Provides water to RCV's, Quick Couplers, and hose bibs. Normally under constant pressure.

K. OAR: Acronym for Owner's Approved Representative. This individual designated by Owner who is authorized to make decisions on behalf of the Owner. This individual is authorized by the Owner to direct actions of the Contractor. This individual shall have detailed involvement in the project and be on Project site at regular intervals.

L. POC: Acronym for Point of Connection. The physical location of the water source for this Project, and the actual components installed connecting to the water source. May require Contractor to provide additional saddles, valves, nipples, fittings, spools etc. to provide water to the Project.

M. RCV: Acronym for Remote Control Valve. An electrically operated 24 VAC valve.

N. Static Pressure: Pressure measured at the POC, with no flow taking place within the system.

O. Water Supply: Potable, and/or Non-Potable, and/or Effluent piping and components, furnished and installed by trades or contractors other than the irrigation contractor; to provide irrigation water to this Project upstream of (prior to) the POC.

1.3 ELIGIBILITY TO BID

A. The minimum level of expectation for Experience and Qualifications required to be eligible to bid the irrigation system on this Project are listed below in this section.

1. See Sections referring to 'Experience, Qualifications and Certifications' for more information and details.
2. Contractor shall follow these requirements at the bid date.

B. Contractor shall be prepared to submit documentation supporting their Experience and Qualifications to the General Contractor and the OAR within 48 hours of bid date. Failure to provide supporting documents within 48 hours of bid may result in elimination of the Contractor's bid or his ability to work on this Project.

C. Failure to meet the minimum requirements for Experience and Qualifications may result in elimination of the Contractor's bid or his ability to work on this Project.

D. Requirements for documentation of Certifications are also listed below in the same Section. Contractor shall not be required to submit documentation of Certification at Bid date, but at date indicated.

1.4 PROJECT CONDITIONS

A. Contractor shall accept Project site in 'as-is' condition.

B. Contractor shall revise, restore, repair existing irrigation system to return to or continue operation of system outside project area of disturbance.

C. Interruption of water service

1. Should irrigation installation require shut-down of existing Project irrigation system, Contractor shall be responsible to coordinate with and receive approval from OAR. Contractor shall be responsible to restore operation of existing irrigation systems within 48 hours.
2. Contractor shall be responsible for continuous provision of irrigation water maintaining all existing or new plant material on Project in a healthy condition during full term of this project.

D. Contractor shall maintain Project work area in a safe condition, and provide flagging, taping, barricades, trench covering, shoring and or fencing necessary to maintain safety.

1.5 PERFORMANCE REQUIREMENTS

A. Minimum pressure and minimum flow required:

1. Irrigation CD's expect that the POC has available a minimum static pressure and a minimum flow capable to safely and efficiently operate irrigation system as designed. Minimum design requirements are listed in plan legend.
2. Contractor shall perform static/working pressure and volume test within 48 hours of commencement of work and provide written results to OAR.

B. Responsibility for coverage:

1. Irrigation system basic design intent is to provide 100% coverage of sprinklers (also known as double coverage or head-to-head coverage.)

2. Contractor shall have authority to make minor adjustments to actual placement of sprinkler heads or irrigation components vs. locations shown on plan, in order to best achieve full coverage indicated above, without significant overspray on hardscapes, buildings or other project features.
3. Contractor shall notify OAR in writing of potential discrepancies or weaknesses due to field conditions; in implementing irrigation CD's.

C. Layout of Components

1. During layout and staking, consult with OAR to verify proper placement of major irrigation components.
2. Contractor shall not proceed with implementation of CD's without OAR's approval.
3. Contractor shall have authority to make minor adjustments to pipe routing or equipment locations due to conflicts with site utilities or other obstructions.

1.6 SEQUENCING

A. Contractor shall contact local utility locator service at least 48 hours prior to commencement of work on the Project.

B. Contractor shall familiarize with himself with site utilities and hazards prior to commencement of work.

C. Contractor shall coordinate this work with other work by other trades on Project as well as other landscape tasks on Project.

D. Install sleeving prior to installation of concrete flat work, paving or other permanent site elements as needed.

E. Irrigation system Point of Connection components, backflow prevention and pressure regulation devices shall be installed and operational prior to all downstream components.

F. All main lines shall be thoroughly flushed of all debris prior to installation of Remote-Control Valves.

G. All lateral lines shall be thoroughly flushed of all debris prior to installation of any sprinkler heads.

1.7 REFERENCE DOCUMENTS

A. The following references apply to this project, the Contractor shall be responsible to be familiar with, refer to, and implement these references in completion of this project:

1. ASTM – American Society for Testing and Materials.
2. Irrigation Association: Turf and Landscape Irrigation Best Management Practices (BMPs).
3. American Society of Irrigation Consultants (ASIC) 'ASIC Guideline 100-2002 (January 2, 2002) For Earth Grounding Electronic Equipment in Irrigation Systems.
4. Utah Irrigation Professionals document: Minimum Standards for Landscape Design and Construction.

5. Any other existing local governing agency codes, ordinances and/or any standards, details and specifications for irrigation agency may have.
6. Applicable industry codes, ordinances or standards such as (but not limited to) UBC or NEC.

B. Generally, this specification section shall take precedence over all others. Any discrepancies discovered by Contractor shall be brought to OAR's attention within 8 hours via telephone and within 48 hours in writing. Contractor shall not proceed with work until OAR provided direction or approval.

1.8 RELATED SPECIFICATION SECTIONS

A. 32 90 00 Landscaping

1.9 SUBMITTALS

A. Contractor shall follow format and requirements as set forth in General Conditions section of this specification document for materials submittals.

B. Contractor shall provide submittal for irrigation equipment and materials prior to ordering or taking delivery of any products.

C. Equipment or materials purchased or installed prior to receiving written submittal approval is at risk of rejection by OAR. Contractor may be liable for removal or replacement of any or all non-approved products at his own expense.

D. Contractor shall provide OAR with 2 copies of Operations and Maintenance manual, containing:

1. Copy of approved submittal products
2. Instruction for Spring Start-up and Winterization.
3. Site map showing Controller zones, each zone distinguished by a different color.
4. Table showing typical Controller program schedule for worst case day.
5. Copy of control system certification if required for this Project.

1.10 EXPERIENCE

A. Contractor shall provide an Experience resume or document; in pdf format, indicating:

1. That Contractor is licensed to perform landscape and irrigation construction in the State where Project resides.
2. That Contractor is bondable and insured for the work to be performed.
3. That Contractor has been installing sprinkler systems on commercial projects for the last five previous years.
4. References of five projects of similar scope and size completed within the last five years. Three of the projects listed shall be local.

1.11 QUALIFICATIONS

A. Contractor shall provide a Qualifications resume or document; in pdf format indicating:

1. That Contractor currently employs both skilled and unskilled workers in enough quantities to complete project within time limits indicated by Contract.
2. A list of employees to be assigned to this project and their irrigation experience.
3. Contractor shall include a listing of the supplier(s) where irrigation related material will be purchased for this Project.
4. That Contractor possesses proper power equipment of appropriate size and quantity to complete project within time limits indicated by Contract.
5. Person on project site, in charge of irrigation daily field operations: (Project Foreman, Superintendent, Supervisor etc.)
    a. Has at least five consecutive years of commercial irrigation experience.
    b. This person can communicate with OAR. Is fluent in reading, writing and speaking English.
    c. Is a Certified Irrigation Contractor (CIC) in good standing as set forth by the Irrigation Association. This person shall be on the project site at least 75% of each working day.
        i. Contractor's CIC shall be a regular full-time employee of the Contractor firm, or a sub-contractor to Contractor, where sub-contractor's firm provides all irrigation installation for the Project and meets all listed requirements for Experience, Qualifications and Certifications.
        ii. NOTE: Contractor shall not engage a CIC as a consultant or representative to oversee Contractor's staff install the Project irrigation system, i.e. the Contractor shall not 'rent' a CIC or CIC's license.

1.12 CERTIFICATIONS

A. Contractor shall provide copies of appropriate Certification documents for all applicable staff. In order to provide a minimum level of workmanship, all installation personnel expected to perform any tasks involving PVC pipe, electrical components, and or drip components; shall have Certificates for each task they perform as designated below:

1. All installation personnel who will work on PVC pipe and PVC fittings in the irrigation system shall be certified by IPS Corporation. The certification shall cover PVC pipe and fitting assembly using solvent weld joining techniques. It is the responsibility of the Contractor to obtain such certification and to provide a copy of the "Certificate of Completion" for each person handling PVC products on the project to the OAR prior to commencement of work. It is the Contractors responsibility to contact IPS Corporation and then the local IPS authorized representative well in advance of commencement of work to schedule his/her attending of a scheduled seminar or to make an appointment to schedule a new seminar. Contact IPS Corporation, Weld-On Customer Service at 800 421-2677, to obtain a referral for the local IPS factory authorized representative contact information.
2. All installation personnel who will work on the electrical circuits of the irrigation system shall be certified by Paige Electric Co., LP. The certification shall cover irrigation wires, cables, proper installation and splicing methods, and protecting electronic equipment from lightning and power surges. It is the responsibility of the

Contractor to obtain such certification and to provide a copy of the "Certificate of Completion" for each person installing electrical products on the project to the OAR prior to commencement of work. It is the Contractors responsibility to contact Paige Electric well in advance of commencement of work to schedule his/her attending of a scheduled seminar or to make an appointment for a new one. Contact Vince Nolletti, Vice President Irrigation Operations, Paige Electric Co, LP, 559 431-2346.

3. If Drip irrigation products are to be used on this Project, all installation personnel who will work on drip components of the irrigation system shall be certified by the manufacturer of the corresponding drip products specified to be used on the Project. The certification shall cover proper application and installation of point source and inline drip irrigation products, and adaptation of drip product to Project soil types and infiltration rates. It is the responsibility of the Contractor to obtain such certification and to provide a copy of the "Certificate of Completion" for each person installing drip products on the project to the OAR prior to commencement of work. It is the Contractors responsibility to contact the drip product manufacturer and the local manufacturer's authorized representative well in advance of commencement of work to schedule his/her attending of a scheduled seminar or to make an appointment for a new one. Courtesy contact information for the following manufacturers is shown below)

    -Rain Bird Corporation—Dave Chandler (801) 664-6798

4. Documents verifying certifications for the following shall be provided to OAR through the General Contractor at least 7 days prior to commencement of any irrigation work on the Project:
    a. PVC Solvent Weld certification
    b. Electrical certification
    c. Drip certification

1.13 QUALITY ASSURANCE

A. Inspection Scheduling

1. Contractor shall expect a minimum of five irrigation inspections:
    a. Main Line pipe and wire
    b. Main Line pressure test
    c. Progress inspection
    d. Final inspection
    e. Completed Punch list inspection

B. Main Line Piping

1. Main line pipe shall not be buried until approved by OAR. Pipe buried prior to approval shall be excavated and exposed for OAR's review.
2. Upon completion of main line pipe or sections thereof, Contractor shall isolate and pressurize to 150 PSI for two hours. OAR shall determine acceptable amount of loss. Contractor shall expect to provide a test with losses not to exceed between 0.5% and 5%
3. Contractor shall provide OAR with 48 hours request prior to testing date and time.

C. Grounding Resistance Testing

1. Pedestal Controllers shall be tested by Licensed Electrical Contractor and show resistance of 10 Ohms or less.
2. Grounding not in compliance shall be corrected by Contractor at his expense.
3. Specific grounding requirements for Central Control systems shall be met by Contractor or corrected at his expense.

D. Project Record Copy

1. Maintain on Project site, one copy of all CD's clearly marked 'Project Record Copy'. Mark any deviation in material installation on CD's. Maintain and update sheets at least weekly.
2. Project Record Copy shall be available to OAR on demand.

E. Regulatory Requirements

1. Contractor shall comply with all plumbing requirements which direct work to be done by a licensed plumber.
2. Contractor shall comply with all electrical requirements which direct work to be done by a licensed electrician.
3. All work and materials shall be according to any and all rules, regulations or codes, whether they are local, state or national requirements.
4. CD's may not be construed or interpreted to permit work or materials not conforming to the above codes.

F. Adequate Water Supply

1. Water supply to this Project is or shall be installed by trades other than the Irrigation Contractor. Connection to this supply at the POC shall be by this Contractor. Contractor shall be responsible to verify that proper connection exists and is of adequate size and pressure.
2. Notify OAR verbally immediately and in writing within 48 hours of problems encountered with water supply.

G. Workmanship and Materials

1. It is the intent of the Irrigation CD's that all material required shall be of the highest quality available and meeting the requirements specified.
2. All work shall be performed in accordance with the best standards of practice relating to this trade.

1.14 PROJECT MATERIALS

A. Owner shall retain option to purchase materials to be used on Project and provide them to Contractor. Owner shall not provide materials for Project.

B. Contractor shall not remove materials purchased for this Project from this site.

C. Contractor shall not store or co-mingle materials for this Project with materials for other Projects on this site.

D. Delivery, Storage and Handling

1. All materials shall be protected from contamination, damage, vandalism and prolonged exposure to sunlight.
2. All material stored on project site shall be neatly organized in a compact arrangement, and this storage shall not disrupt project owner or other trades on Project site.
3. Project materials shall be handled by Contractor with care necessary to prevent damage or breaking.
4. Damaged or blemished materials attributed to Contractor shall be replaced with new, at Contractors expense.

E. If this Project qualifies for manufacturer rebate, credit or incentive programs; Contractor shall provide OAR with documents in pdf format from distributor and/or manufacturer indicating required information of product purchased and/or dollar value which qualify for corresponding program. Documents shall be delivered within 14 days of purchase of products.

1.15 EXTRA MATERIALS

A. Furnish the following items to OAR:

1. One (1) 30" gas cock key (also referred to as sprinkler or meter key) for manual drains.
2. One (1) 5-6' key for 2" square operating nut valve.
3. One (1) 5-6' key for stop & waste valve.
4. Two (2) keys for each automatic controller.
5. Two (2) quick coupler keys with hose swivels attached.
6. One (1) quick coupler valve.
7. One (1) of each size or type of remote-control valve used on Project.
8. Five (5) of each sprinkler head and each nozzle used on Project.
9. Two (2) of each type of specialty screwdriver/key/wrench/tool (used to adjust arc, radius, change nozzle etc.) for each type of sprinkler.

1.16 WARRANTY

A. Contractor shall provide one-year Warranty for Project. Warranty shall cover all material, workmanship and labor.

B. Warranty period begins upon date of acceptance by OAR that Project is substantially complete.

C. Warranty shall include filling and/or repairing depressions, replacing turf or other plantings due to settlement of irrigation trenches or irrigation system components, and adjustment of valve boxes, sprinkler heads and all other irrigation components which have settled from proper finish grade.

1.17 ADDITIONAL SERVICES

A. Winterization:

1. Contractor shall winterize entire irrigation system installed under this Contract prior to the first winter following installation; prior to hard frost--but no later than November 15th, unless directed otherwise by OAR in writing.
2. Winterize entire system via 'blow-out' method, using compressed air.
   a. Compressor shall be industrial type, capable of evacuating water from all main line and lateral line pipe, with a minimum capacity of 185 CFM.
   b. Compressor shall be mechanically regulated to not more than 60 PSI.

B. Spring Start-up:

1. Contractor shall start up entire irrigation system the Spring following installation; prior to plant need--but following danger of damaging frost, yet no later than April 15th.
2. Contractor shall energize entire main line pipe, all RCV's, and check for correct program installation and operation of Controller, each RCV and each quick coupler valve.

C. As-built documents: Prior to final inspection, prepare and submit to OAR As-built drawings.

1. Show field dimensioned locations of sleeving, POC, mainline piping, wiring runs not in main line pipe trench, and valves/valve boxes.
2. Dimensions are to be taken from permanent site features or finished hardscapes.

1.18 OWNER'S INSTRUCTION

A. After system is installed, inspected, and approved; Contractor shall instruct OAR or other OAR designated individuals in complete operation and maintenance procedures of irrigation system. Coordinate instruction with references to previously submitted Operation and Maintenance manual.

PART 2 - PRODUCTS

2.1 GENERAL NOTES

A. Contractor shall use products as specified by CD's.

2.2 POWER SOURCE

A. Power source for irrigation equipment shall not be included in the irrigation Contractor's portion of this Contract.

2.3 CENTRAL CONTROL SYSTEM

A. A Central Control System is not included in this Project. Central Control equipment is not included in this project.

2.4 CONTROLLER

A. Manufacturer and model shall be as listed on plan legend.

B. Contractor shall connect control wires and power wires to controller.

C. Controller shall be wall mounted interior.

D. Exterior wall mount controllers shall use rigid galvanized steel electrical conduit for all wiring.

E. PVC pipe, conduit sweeps, and fittings shall not be used for any controller wiring.

2.5 POWER WIRE

A. DIRECT BURY WIRE FOR FIELD LOCATED WALL OR PEDESTAL MOUNTED CONTROLLERS:

1. All power cables shall be Paige Wire, type Tray Cable.
2. Wire shall be Paige Wire specification number P7266D for 10 AWG and smaller.
3. Wire shall be Paige Wire specification number P7267D for 8 AWG and larger.
4. 120 VAC wires shall be 3 conductors (hot, neutral and ground)
5. 240 VAC cables where service is provided to controller only, shall be 3 conductors (2 hot and 1 ground)
6. 240 VAC cables where service is provided to controller and other 120 VAC equipment (such as a convenience outlet) shall be 4 conductors (2 hot, 1 neutral and 1 ground)

B. CONVENTIONAL WIRING FOR WALL MOUNTED CONTROLLERS:

1. Power wire or cable for conventionally wired wall mount or conduit-fed pedestal mount shall be according to local and NEC codes.

2.6 CONTROL WIRE

A. Remote Control Valve wire shall be Paige Electric specification number P7079D.

B. Common wire shall be white in color, 12 AWG, Paige part number 150170.

C. Control or 'hot' wire for projects with a single controller shall be red in color, 14 AWG, Paige part number 150040.

D. Spare wire shall be orange in color, 14 AWG, Paige wire.

E. Trace wire shall be Yellow in color, 14 AWG, Paige wire.

F. Master Valve wire shall be blue in color, 14 AWG, Paige wire.

G. NO SUBSTITUTIONS ALLOWED.

2.7 COMMUNICATION WIRE

A. Communication wire/Sensor wire shall be Paige brand, model 7171D or P7315D (PE 39).

2.8 WIRE CONNECTORS

A. RCV wire splicing connectors and Decoder wire splicing connectors shall be Paige P7364D, Paige part number 270670 or 270671 (3M model 'DBY/R'). No substitutions allowed.

B. Communication wire splicing or connection shall be Paige brand, model 273211 (3M model SliC) and Paige brand, model 270228R (3M model 316IR). No substitutions allowed.

2.9 POINT OF CONNECTION

A. Precise or specific products required of Contractor for installation of the POC are unknown. Contractor shall be prepared for a variety of POC conditions including:

1. Tapping, Saddling, Pac-Joint connection, extension, flared end connectors.

B. Stop & Waste Valve

1. POC's with connection sizes 1" through 2"
2. Mueller Oriseal H-10288 1" – 2"
3. Cambridge Brass 263NL-FXFX 1" – 2"

2.10 MASTER VALVE

A. Manufacturer and model shall be as listed on plan legend.

2.11 FLOW METER

A. Manufacturer and model shall be as listed on plan legend.

2.12 SLEEVING PIPE

A. Minimum sleeve size shall be 2" pipe.

B. Sleeving 2" through 4" shall be S/40 PVC pipe. Sleeving 6" and larger shall be CL/200 PVC pipe.

C. Sleeves shall typically be two nominal sizes larger than the pipe to be placed within them. Sleeve material and sizes shall be according to the following SLEEVING TABLE:

INTERIOR PIPE	SLEEVE PIPE		INTERIOR PIPE	SLEEVE PIPE
¾" S/40	2" S/40		4" CL/200	8" CL/200
1" S/40	2" S/40		6" CL/200	10" CL/200
1-1/4" S/40	2-1/2" S/40		8" CL/200	12" CL/200
1-1/2" S/40	3" S/40		10" CL/200	14" C905
2" S/40	4" S/40			
3" S/40	6" CL/200			

2.13 MAIN LINE PIPE

A. Pipe 1" through 3" shall be S/40, solvent weld-bell end.

B. Pipe 4" through 12" shall be CL/200 gasketed-bell end.

C. Yelomine pipe with grooved ends and couplers shall be used for above grade applications such as bridge crossings.

2.14 MAIN LINE FITTINGS

A. All main line fittings 3" and smaller shall be S/80.

B. All main line fittings 4" and larger shall be mechanical joint, or 'MJ'.

C. All MJ fittings shall include megalug restraints.

2.15 MANUAL CONTROL VALVES

A. Line or isolation valves 2-1/2" and larger shall be:

1. Matco Norca model 200 RTD ductile iron resilient wedge push on w 2" square operating nut.
2. Matco Norca model 200 WD ductile iron resilient wedge flanged with 2" square operating nut.
3. Matco Norca model 200 MD ductile iron resilient wedge Mechanical Joint (MJ) with 2" square operating nut.

B. Line or isolation valves 2" and smaller shall be:

1. Matco Norca model 503 bronze gate valve OR
2. Milwaukee model 105 bronze gate valve OR
3. Hammond model IB645 bronze gate valve

C. Isolation valves for RCV Manifolds (1" through 2-1/2") shall be:

1. Matco Norca model 503 bronze gate valve OR
2. Milwaukee model 105 bronze gate valve OR
3. Hammond model IB645 bronze gate valve

D. Drain Valves shall be:

1. ¾" Mueller Oriseal model H-10288.
2. ¾" Cambridge Brass model 263NL-F3F3.

2.16 QUICK COUPLER VALVE

A. Manufacturer and model shall be as listed on plan legend.

B. Swing joint for 1" quick coupler valves shall be Lasco model 13S-212 factory assembled swing joint.

C. Swing joint for ¾" quick coupler valves shall be Lasco model 13T-212 factory assembled swing joint.

D. No substitutions for quick coupler swing joint shall be accepted.

2.17 VACUUM/AIR RELIEF VALVE

A. Manufacturer and model shall be as listed in plan legend.

B. Additional product necessary for installation and operation of vacuum/air relief valve shall be indicated on plan detail sheet.

C. Contractor shall submit for approval, vacuum/air relief valve and assembly components.

2.18 REMOTE CONTROL VALVE

A. Manufacturer and model shall be as listed on plan legend.

B. Union assembly products shall be as listed on plan detail sheet.

C. Contractor shall submit for approval; remote control valve and all components necessary to complete installation of valve.

2.19 VALVE BOXES

A. Carson Industries Specification Grade valve boxes shall be used on this project unless otherwise indicated.

2.20 LATERAL LINE PIPE

A. All lateral piping shall be new, S/40 PVC, solvent weld bell end. Sized as indicated on plans.

2.21 LATERAL LINE FITTINGS

A. All lateral line fittings shall be new S/40 PVC.

2.22 MEDIUM ROTOR HEAD SPRINKLERS

A. Manufacturer and model shall be as listed on plan legend.

B. Nozzles for medium rotor heads shall be as listed on plan legend.

C. All rotor heads shall be on a swing joint assembly composed of one 12" S/80 nipple (extruded, cut and threaded—not molded), and three marlex street elbows. Swing joint fittings shall be same size as inlet on head.

D. Contractor shall submit for approval rotor heads and swing joint components.

2.23 ROTARY NOZZLE SPRAY HEAD SPRINKLER

A. Manufacturer and model shall be as listed on plan legend.

B. Rotating type nozzles for spray heads shall be as listed on plan legend.

C. All small rotor sprinklers shall be on a swing joint assembly composed of 12-24" of swing pipe, two ½" spiral barb elbows, 12-24" swing pipe, one M412-005 ½" marlex street elbow.

D. Contractor shall submit for approval spray heads, rotary nozzles, swing pipe, spiral barb elbow, and marlex street elbows.

2.24 SPRAY HEAD SPRINKLER

A. Manufacturer and model shall be as listed on plan legend.

B. Nozzles for spray heads shall be as listed on plan legend.

1. Nozzles shall be fixed spray type whenever possible, adjustable arc nozzles shall be used only when a fixed spray model is not available.

C. All spray heads shall be on a swing joint assembly composed of 12-24" of swing pipe, two ½" spiral barb elbows, 12-24" swing pipe, one M412-005 ½" marlex street elbow.

D. Contractor shall submit for approval: spray heads, spray head nozzles, and swing joint assembly components.

2.25 DRIP COMPONENTS

A. Drip components shall be manufacturer and model as listed on plan legend or details.

2.26 GLUE AND PRIMER

A. Sprinkler pipe glue shall be IPS Weld-On model 711.

B. Sprinkler pipe primer shall be IPS Weld-On model P-70.

C. No substitutions allowed.

PART 3 - EXECUTION

3.1 GENERAL NOTES

A. Contractor shall repair or replace work damaged by irrigation system installation.

B. If damaged work is new, Contractor shall engage original installer of that work to perform repairs.

C. The existing landscape of this Project shall remain in place. Contractor shall protect existing plant material and work around existing plant material as necessary.

D. Plant material deemed damaged by OAR shall be replaced at Contractor's expense.

E. Contractor shall route pipe, wire and other irrigation elements around outside of tree canopy drip line to minimize damage to tree roots.

F. Contractor shall not cut existing tree roots larger than 2" to install this Project.

G. Coordination of trench and valve locations shall be laid out with OAR prior to any excavation occurring.

H. Contractor shall have no part of existing irrigation system used by other parts of Project landscape without water for more than 48 hours.

3.2 POWER SOURCE

A. Power supply to irrigation controller (Strong Box installation and Meter base with load center) shall not be included in the irrigation portion of this Project. Power supply shall be a part of other Contracts associated with this Project. See Electrical Construction Documents and Specifications for information and/or detail. Controller power wire from load center(s) to Controller shall be a part of this Contract.

B. Pedestal mount controllers shall have Paige Wire grounding grid installed per Section 1.05 C. of this document.

C. Locate Controllers in general location shown on Construction drawings. Coordinate power supply and breaker allocation with electrical contractor. Contractor shall be responsible for all power connections to Controllers, whether they are wall mount or pedestal mount. Contractor shall coordinate with electrical or other Project trades as needed to facilitate installation of power to controllers.

3.3 CONTROLLER

A. All grounding shall be as directed by controller manufacturer and ASIC guidelines, not to exceed a resistance reading of 10 OHMs.

B. Locate controllers in protected, inconspicuous place when possible.

C. Coordinate location of pedestal controllers with OAR to minimize visibility.

D. Coordinate location of wall mount controllers with building or electrical Contractor to facilitate electrical service and future maintenance needs. Wall mount shall be securely fastened to surface. If exterior mounted, wall mount controllers shall have electrical service wire and field control wire in separate, appropriately sized weatherproof electrical conduit, PVC pipe shall not be used.

E. Wire under hardscape surfaces shall be placed continuously in conduit.

F. Pedestal controllers shall be placed upon VIT-Strong Box Quick Pad as per manufacturer's recommendations.

G. Controllers shall be oriented such that Owner's Representative maintenance personnel may access easily and perform field system tests efficiently.

H. Place Standard valve box at base of controller or nearby to allow for three to five feet of slack field control wire to be placed at each controller.

I. This Contractor shall provide conduit access if needed for Electrical contractor. Electrical supply and installation, as well as hook-up to controller shall be by this Contractor.

3.4 CONTROL WIRE

A. One spare wire from every valve grouping containing three or more valves shall be 'home run' to the controller.

B. Install at least one spare wire for every five valves.

C. Total number of spare wires shall not be less than 1/5th of the total control valves installed.

D. Spare wire shall be looped within each valve box of the grouping it is to service.

E. A minimum of 24" of additional wire shall be left at each valve, each splice box and at each controller.

3.5 WIRE CONNECTORS

A. Wire splicing between controller and valves shall be avoided if possible.

B. Any wire splices shall be contained within a valve box.

C. Splices within a valve box that contains no control valves shall be stamped 'WIRE SPLICE' or 'WS' on box lid.

3.6 SLEEVING PIPE

A. Sleeves shall be extended 6" minimum beyond walk or edge of pavement.

B. Wire or cable shall not be installed in the same sleeve as piping, but shall be installed in separate sleeves.

C. Sleeve ends on sleeve sizes 4" and larger shall be capped with corresponding sized PVC slip cap, pressure fit, until used, to prevent contamination.

D. Sleeve ends on sleeve sizes 3" and smaller may be thoroughly taped to prevent contamination.

E. Sleeves shall be installed at appropriate depths for main line pipe or lateral pipe

F. Contractor shall be responsible to protect existing underground utilities and components.

G. Sleeve all piping and wiring that pass under paving or hardscape features.

H. Sleeves shall be positioned relative to structures or obstructions to allow for pipe or wire within them to be removed if necessary.

3.7 MAIN LINE / LATERAL LINE PIPE

A. All fittings 3" and larger having change of direction shall have proper concrete thrust block installed.

B. Pulling of pipe shall not be permitted on this project.

C. Over excavate trenches both in width and depth. Ensure base of trench is rock or debris free to protect pipe and wire. Grade trench base to ensure flat, even support of piping. Backfill with clean soil or import material.

D. Contractor shall backfill no less than 2" around entire pipe with clean, rock free fill.

E. Main line piping and fittings shall not be backfilled until Designer or Owner's Representative has inspected and pipe has passed pressure testing. Perform balance of backfill operation to eliminate any settling.

F. Place irrigation pipe and other elements at uniform grades. Automatic drains shall not be installed on this Project. Manual drains shall only be installed at POC where designated on Construction Drawings.

G. Install pipe to allow for expansion and contraction as recommended by pipe manufacturer.

H. Install main line pipes with 18" of cover, lateral line pipes with 12" of cover.

I. Drawings show diagrammatic or conceptual location of piping—Contractor shall install piping to minimize change of direction, avoid placement under large trees or large shrubs, avoid placement under hardscape features.

J. Plastic pipe shall be cut squarely. Burrs shall be removed; spigot ends of pipes 3" and larger shall be beveled.

K. Pipe shall not be glued unless ambient temperature is at least 50 degrees F. Pipe shall not be glued in rainy conditions unless properly tented.

L. All solvent weld joints shall be assembled using IPS 711 glue and P70 primer according to manufacturer's specification, no exceptions.

M. Glued main line pipe shall cure a minimum of 24 hours prior to being energized. Lateral lines shall cure a minimum of 2 hours prior to being energized and shall not remain under constant pressure unless cured for 24 hours.

N. All threaded joints shall be wrapped with Teflon tape or paste unless directed by product manufacturer or sealing by o-ring.

O. All main line pipe, lateral line pipe and other irrigation elements shall be bedded and backfilled with clean soil, free of rocks 1" and larger.

P. Contractor shall furnish and install additional backfill material as necessary due to rocky conditions.

Q. Trenches and other elements shall be compacted and/or water settled to eliminate settling.

R. Debris from trenching operations un-usable for fill shall be removed from project and disposed of properly by Contractor.

S. Maximum acceptable flow through piping shall be 5.0 FPS maximum flow through piping shall be:

1. 1"—13 GPM
2. 1-1/4"—22 GPM
3. 1-1/2"—30 GPM
4. 2"—50 GPM
5. 2-1/2" 75 GPM

3.8 MANUAL CONTROL VALVE

A. For 3" and larger valves, place sleeve of 6" or larger pipe over top of valve vertically and then extend to grade. Place 10" round valve box over sleeve at grade. See detail for additional information.

B. Isolation valves 2-1/2" and smaller shall be contained in a Carson Standard size valve box. Valves shall be installed with S/80 PVC TOE Nipples one both sides of valve.

3.9 QUICK COUPLER VALVE

A. Quick coupler valves shall be placed with manifold groups and protected by manifold isolation valves.

B. Top of quick coupler valve cover shall allow for complete installation of valve box lid, but also allow for insertion and operation of key.

C. Base of quick coupler valve and top of quick coupler swing joint shall be encased in ¾"-gravel.

D. Contractor shall not place quick coupler valves further than 200 feet apart, to allow for spot watering or supplemental irrigation of new plant material.

E. Quick coupler valve at POC shall not be eliminated or relocated.

3.10 REMOTE CONTROL VALVE

A. Contractor shall place remote control valves in groups as practical to economize on quantity of manifold isolation valves.

B. Remote control valves shall be located separately and individually in separate control boxes.

1. Flows through 1" valves shall be 1-25 GPM.
2. Flows through 1-1/2" valves shall be 26-50 GPM.
3. Flows through 2" valves shall be 51 through 75 GPM
4. Flows through 3" valves shall be 76 GPM through 200 GPM.

C. Valves shall be in boxes with ample space surrounding them to allow access for maintenance and repair.

D. Where practical, group remote control valves in proximity, and protect each valve with a manifold isolation valve as shown in details. Valve boxes shall be set over valves so that all parts of the valve can be reached for service. Valve box and lid shall be set to be flush with finished grade.

E. Only one remote control valve may be installed in a Carson 1419124 box.

F. Place a minimum of 4" of ¾" washed gravel beneath valve box for drainage.

G. Bottom of remote-control valve shall be a minimum of 2" above gravel.

H. See remote control valve manifold detail for more information.

3.11 DRIP COMPONENTS

A. Planting beds shall be graded to continuous uniform finish grade prior to tubing installation. Surface installed drip tubing shall be installed after plant material, but prior to bark mulch being installed. Tubing shall be installed with equal spacing between lateral runs of tubing. Tubing shall be adequately staked or stapled to the soil surface to prevent tubing from penetrating bark surface. Any tubing visible at bark surface shall be re-installed and re-stapled at Contractor expense.

B. Sub-surface drip tubing shall be installed at uniform depth and uniform lateral spacing using small powered pipe puller or other similar method. Care shall be taken to prevent contamination with soil in tubing.

C. Contractor shall place filters, regulators, air/vac vents and flush valves as necessary to meet manufacturer's minimum recommendations.

D. Field conditions, specifically soil type conditions shall dictate any alteration in emitter size, emitter spacing and row spacing. Contractor shall notify OAR to request confirmation of soil type prior to ordering drip tubing products to ensure proper product and proper spacing are used.

3.12 SYSTEM ADJUSTMENT

A. Sprinkler heads shall be adjusted to proper height when installed.

B. Changes in grade or adjustment of head height after installation shall be considered a part of the original contract and at Contractor's expense.

C. Adjust all sprinkler heads for arc, radius, proper trim and distribution to cover all landscaped areas that are to be irrigated. Adjust sprinklers so they do not water buildings, structures, or other hardscape features.

D. Adjust run times of stations to meet needs of plant material the station services.

E. No sprinkler shall be located closer than 6" to walls, fences, or buildings.

F. Heads adjacent to walks, curbs, or paths shall be located at grade and 2" away from hardscape.

G. Control valves shall be opened and fully flush lateral line pipe and swing joints prior to installation of sprinklers.

H. Spray heads shall be installed and flushed again prior to installation of nozzles.

I. Contractor shall be responsible for adjustment if necessary due to grade changes during landscape construction.

3.13 CLEANUP

A. Contractor shall clean all work areas daily, leaving areas accessible to the public in a 'broom clean' condition.

B. Open trenches and or hazards shall be protected by chain link fence, snow fencing, or caution tape as directed by the OAR.

C. Contractor shall coordinate with OAR for periodic as well as final cleanliness inspection.

D. Upon project completion, Contractor shall remove all excess material, construction debris, packing, etc. attributable to his work.

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DIVISION 33
UTILITIES

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SECTION 33 05 01
HIGH DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The Contractor shall provide high density polyethylene pipe and appurtenances, complete in place, in accordance with the Contract Documents.

1.2 RELATED SECTION

A. Section 31 23 00 – Earthwork

1.3 REFERENCES

A. The Materials and Work furnished shall be, as a minimum, in accordance with the latest editions of the following standards except as such Standard are modified and supplemented in this section.

AWWA C906	Standard for Polyethylene (PE) Pressure Pipe & Fittings, 4 inch (100 mm) through 63 inch (1,575 mm) for Water Distribution and Transmission
ASTM D1238	Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1248	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D2837	Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
ASTM F714	Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM D3035	Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3261	Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

ASTM D256	Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
ASTM D2683	Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM F1055	Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
ASTM D2657	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
ASTM F2164	Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure
ASTM F1417	Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
PPI TR-33	Generic Butt Fusion Joining Procedure for Field Joining of PE Pipe

1.4 SUBMITTALS

A. The Contractor shall submit the following information and data. See Section 01 30 20 – Contractor Submittals.
   1. Product Data: Provide data indicating pipe, pipe accessories and fittings.
   2. Manufacturer's Installation Instructions: Indicate special procedures required to install products specified.
   3. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
   4. Certified Resin Test Reports covering the physical, stress, regression, thermal and impact tests of resin material to be used for the pipe. Submit this information prior to manufacturing or fabricating any pipe.
   5. Proposed butt fusion procedures including training and qualification requirements and joint repair procedures shall be submitted to the Engineer for review and approval.
   6. Qualifications of Butt Fusion Welders and Welding Operators
      a. All butt fusion welders and welding operators shall be qualified and certified for all portions of the work specified in this section. Welder qualification requires that during the past 12 months all welders and welding operators have successfully completed certified butt-fusion joints using the pipe and welding machine proposed for this project.
      b. Current welder and welding operator performance qualification test records shall be submitted to the Engineer for review and approval prior to commencing field operations.
      c. Personnel that will be operating the butt fusion welder shall be certified by either 1 and 3, or 2 and 3 of the following criteria:

1) Previous demonstrated experience during the past 12 months, in the use of the procedure on similar projects using the same welding machines and type of pipe proposed.
2) Appropriate training and apprenticeship
3) All operators shall make a specimen joint from the pipe to be used on the project. This joint shall then be subjected to the test requirements specified herein.

7. Fusion parameters including the recommended limits of all criteria recorded by the data logger.
8. Fusion report for each joint, which shall include the following information.
   a. Pipe size and dimensions
   b. Machine size
   c. Operator identification
   d. Job identification number
   e. Weld number
   f. Fusion, heating and drag resistance settings
   g. Heater plate temperature
   h. Time Stamp
   i. Heating and curing time of weld
   j. Curing temperature readings and time stamps of readings
   k. Ambient air temperature and humidity
   l. Error message and warnings for out of range temperature or pressure settings.

1.5 REGULATORY REQUIREMENTS

A. Conform to applicable codes for materials and installation of the Work in this Section.

1.6 PROJECT CONDITIONS

A. Coordinate the Work on pipelines and connections to existing pipelines with the Owner.

1.7 QUALITY CONTROL

A. Any pipe manufactured prior to review and approval of all required prefabrication submittals will be at the Contractor's own risk.

B. Review of the Contractor's shop drawings shall not relieve the Contractor of any responsibility for accuracy of dimensions and details, nor shall mutual Agreement of dimensions or details relieve the Contractor of responsibility for Agreement and conformity of its Shop Drawings with the Contract.

1.8 QUALITY ASSURANCE

A. Fabrication, processing, testing and inspection operations affecting the pipe and associated accessories shall, at any time, be subject to quality assurance surveillance by Owner, or Engineer. Such surveillance shall be at the discretion of the Owner. Such surveillance does not relieve the Contractor from responsibility for the Work.

B. All deviations from this specification section must be documented and referred to Engineer for resolution.

C. The Contractor shall submit to the Engineer an affidavit from the manufacturer that the pipe, specials, fittings, and other products of material furnished under this Contract comply with all applicable provisions of AWWA C906 standards and this specification.

D. DOCUMENTATION: The following items shall be documented and stored as part of the manufacturer's permanent records. Copies of all documentation shall be provided to the Engineer.

1. Documentation from the resin's manufacturer showing results of the following tests for resin identification:
    a. Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer, ASTM D1238
    b. Standard Test Method for Density of Plastics by the Density - Gradient Technique, ASTM D1505
2. The polyethylene pipe manufacturer shall provide certification that stress regression testing has been performed on the specific polyethylene resin being utilized in the manufacture of this product. This stress regression testing shall have been done in accordance with ASTM D2837 and the manufacturer shall provide a product supplying a minimum Hydrostatic Design Basis (HDB) of 1,600 psi as determined in accordance with ASTM D2837.
3. Production staff shall check each length of pipe produced for the items listed below. The results of all measurements shall be recorded on production sheets, which becomes part of the manufacturer's permanent records.
    a. Pipe in process shall be checked visually, inside and out for cosmetic defects (grooves, pits, hollows, etc.)
    b. Pipe outside diameter shall be measured using a suitable periphery tape to ensure conformance with ASTM D3035.
    c. Pipe wall thickness shall be measured at 12 equally spaced locations around the circumference at both ends of the pipe to ensure conformance with ASTM D3035.
    d. Pipe length shall be measured.
    e. Pipe marking shall be examined and checked for accuracy.
    f. Pipe ends shall be checked to ensure they are cut square and clean.
    g. Subject inside surface to a "reverse bend test" to ensure the pipe is free of oxidation (brittleness).
    h. Copies of all manufacturer documentation shall be submitted to the Engineer for review and approval upon completion of manufacturing.

E. In addition to those tests specifically required, the Engineer may request additional samples of any material for testing by the Owner. The additional samples shall be furnished as a part of the Work.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Contractor shall comply with the following minimum requirements:
   1. Referenced standards for all materials, processes, methods, tests, etc to be used in completion of the Work.
   2. Delivery of all pipe and materials, all aspects of which shall be conducted in such a manner as to minimize handling, provide proper weather protection and storage, and to meet schedule requirements.
   3. Furnish and use load rated nylon-type slings for securing, lifting, and unloading pipe sections; or, the use of acceptable protective wraps to minimize damage from the alternate rigging equipment.
   4. Internal timber bracing shall be provided to maintain pipe shape and integrity throughout plant storage, transportation, and site storage operations through installation and backfill placement. Internal bracing shall not be removed until a minimum of 2 feet of compacted trench zone material is placed above the top of the pipe.

2.2 MANUFACTURER

A. All HDPE pipe and HDPE fittings shall be from a single manufacturer, who is fully experienced, reputable and qualified in the manufacture of the HDPE pipe to be furnished. The pipe shall be designed, constructed and installed in accordance with the best practices and methods and shall comply with these Specifications. Qualified manufacturers shall be: PLEXCO Division of Chevron Phillips Chemical Company, DRISCOPIPE as manufactured by Chevron Phillips Co., Inc., WL Plastics or equal as approved by the Engineer.

2.3 PIPE IDENTIFICATION

A. The following shall be continuously indent printed on the pipe or spaced at intervals not exceeding 5-feet:
   1. Name and/or trademark of the pipe manufacturer.
   2. Nominal pipe size.
   3. Dimension ratio.
   4. The letters PE followed by the polyethylene grade in accordance with ASTM
   5. D1248 followed by the hydrostatic design basis of 1600 psi, e.g., PE 4710.
   6. Manufacturing standard reference, e.g., ASTM D-3035, as required.
   7. A production code from which the date and place of manufacture can be determined.
   8. Color Identification, either striped by co-extruding longitudinal identifiable color markings or shall be solid in color and as follows:
      a. BLUE – Potable Water
      b. GREEN – Sanitary Sewer
      c. LAVENDER – IQ cover all

B. Marking Tape: Marking tape shall be provided and installed as shown in Drawings and per Engineer approval.

2.4 COMPATIBILITY

A. Contractor is responsible for compatibility between pipe materials, fittings and appurtenances.

2.5 WARRANTY

A. The pipe Manufacturer shall provide a warranty against manufacturing defects of material and workmanship for a period of ten years after the final acceptance of the project by the Owner. The Manufacturer shall replace at no expense to the Owner any defective pipe/fitting material including labor within the warranty period.

2.6 MATERIALS

A. Materials used for the manufacture of polyethylene pipe and fittings shall be made from a PE 4710 high density polyethylene resin compound meeting a minimum cell classification 445574C per ASTM D3350 and ASTM F714.

B. High Density Polyethylene (HDPE) pipe shall be manufactured in accordance with AWWA C901-96 for sizes ½-inch through 3-inch diameters and to the requirements of ASTM D 3035. Pipe 4-inches and above shall be manufactured to the requirements of ASTM F714 and AWWA C906-99.

C. Unless otherwise noted, diameters shown in the Contract Documents shall refer to Iron Pipe Size (IPS) system conforming to the requirements of AWWA C906.

D. If rework compounds are required, only those generated in the Manufacturer's own plant from resin compounds of the same class and type from the same raw material supplier shall be used. Clean rework material of the same type grade, and cell classification generated from the manufacturers own pipe and fitting production may be used by the same manufacturer as long as the pipe, tubing and fittings produced meet all requirements of AWWA C906.

E. Dimensions and workmanship shall be as specified by ASTM F714. HDPE fittings and transitions shall meet ASTM D3261. HDPE pipe shall have a range of density 0.956-0.964 grams per cubic centimeter. All HDPE pipe and fittings shall have a Hydrostatic Design Basis (HDB) of 1,600 psi at 73.0°F in accordance with ASTM D2837.

F. The extruded pipe shall have impact strengths greater than 42 in-lb/in in accordance with ASTM D256 Method A, with a material thickness representative of the cross-section in which the material is to be used.

G. The pipe Manufacturer shall certify compliance with the above requirements.

2.7 FABRICATION

A. Pipe shall be homogenous throughout and uniform in color, opacity, density and other properties as prescribed in the Resin Manufacturers Specifications. The inside and outside surfaces shall be semi-matte to glossy in appearance and free from sticky or tacky material. The pipe walls shall be free from cuts, cracks, holes, blisters, voids, foreign inclusions, or other defects that are visible to the naked eye that may affect wall integrity.

B. Pipe dimensions and wall thickness variations shall be in conformance with requirements of AWWA C906.

C. Pipe shall be finished smooth throughout all inside surfaces and true to all specified tolerances circumference and diameter such that: The difference between maximum and minimum diameters, at any cross-section along the length of the pipe does not exceed 1% of the nominal diameter.

D. Special pipe sections, fittings, and special pieces shall be completely fabricated in the shop. All pipe fittings shall be fabricated or molded to correct dimensions throughout the entire length. Ends cuts shall be clean, squarely-made, and suitable for field welding, without drawn, ragged, gouged, or split ends.

E. All HDPE fittings, unless noted otherwise on the drawings shall be fabricated in conformance with the requirements of AWWA C906. Molded fittings shall meet the requirements of ASTM D3261 for butt-type fittings and this specification.

2.8 FITTINGS

A. All molded fittings and fabricated fittings shall be fully pressure rated to match the pipe SDR pressure rating to which they are made. All fittings shall be molded or fabricated by the manufacturer. No Contractor fabricated fittings shall be used unless approved by the Engineer.

B. Polyethylene fittings furnished under this specification shall be manufactured using compounds complying with the requirements of HDPE pipe above and all appropriate requirements of AWWA C906. Socket fittings shall comply with ASTM D2683, Butt Fusion fittings shall comply with ASTM D3261. Electrofusion fittings shall comply with ASTM F1055. Mechanical fittings (e.g. back-up rings, etc.) shall be of stainless steel, including stainless steel hardware, as indicated in the drawings and shall be approved only after submission of appropriate test data and service histories indicating their acceptability for intended service. In all cases, the specification and requirements for the fittings supplied shall comply with the appropriate sections of AWWA C906 and must be approved by the Engineer. NO size on size wet taps shall be permitted.

C. The manufacturer of the HDPE pipe shall supply all HDPE fittings and accessories as well as any adapters and/or specials required to perform the work as shown on the Drawings and specified herein.

2.9 SHIPPING, STORAGE & HANDLING

A. All materials shall be properly loaded so that they will not bear on each other, and shall be braced to prevent damage to material during shipping. Pipe shall be stacked on level ground and per the manufacturer's recommendations to prevent pipe from becoming out of round.

B. All loose parts shall be crated or boxed for shipping, appropriately identified and shipped with the associated pipe sections.

C. Contractor shall protect pipeline sections stored at the site from damage, including weather and vandalism.

D. Pipes shall be stored on level ground, preferably turf or sand, free of sharp objects, which could damage the pipe OR on wooden sleepers, spaced suitably and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports. Stacking of the polyethylene pipe shall be limited to a height that will not cause excessive deformation of the bottom layers of pipes under anticipated temperature conditions. The Contractor shall abide by the required handling techniques specified by the Supplier.

E. The handling of the pipe shall be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects

F. All piping products shall be kept free from dirt, grease, all petroleum based products, and other foreign matter.

G. The Contractor shall provide suitable lifting equipment, slings, spreader bars, rigging etc needed to handle the pipe. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it is subjected. The use of cables and chains is prohibited.

H. The Contractor shall be responsible for the pipe until such time as it is installed and accepted by the Engineer.

I. The Contractor shall remove any temporary attachments to special components for installation by the Supplier for transportation purposes.

2.10 BEDDING AND COVER MATERIALS

A. Pipe bedding Material: As specified in Section 31 23 00 – Earthwork and in Drawings

PART 3 - EXECUTION

3.1 INSTALLATION – HDPE PIPING

A. High Density Polyethylene (HDPE) Pipe shall be installed in accordance with the instructions of the manufacturer, as shown on the Drawings and as specified herein. A factory qualified joining technician as designated by the pipe manufacturer shall perform all heat fusion joints.

B. Under no circumstances shall the pipe or accessories be dropped into the trench or forced through a directional bore upon “pull-back”.

C. The maximum allowable depth of cuts, scratches or gouges on the exterior of the pipe is 5 percent of wall thickness. The interior pipe surface shall be free of cuts, gouges or scratches. Sections of pipe with cuts, scratches or gouges exceeding 5 percent of the pipe wall thickness shall be removed completely and the ends of the pipeline rejoined. Repair of damaged pipe during or after installation shall conform to the fabricator’s repair procedures or by an Engineer approved repair method.

D. When laying pipe is not in progress, the open ends of the pipe shall be closed by fabricated plugs, or by other approved means.

E. The interior of the pipe shall be cleaned of any foreign matter before being lowered in the trench and kept clean during placement, joint welding, bedding and backfilling operations by plugging or other approved method. Groundwater shall not be permitted to enter the pipe. The full length of each pipe section and each bend shall rest solidly on the compacted bedding material.

F. All HDPE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction.

G. If a defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional cost to the Owner. All pipe and fittings shall be thoroughly cleaned before installation, shall be kept clean until they are used in the work and when laid, shall conform to the lines and grades required.

H. Contractor shall install HDPE pipe when the ambient air temperature conforms to manufacturer's specifications. The Contractor will be responsible for verifying the temperature by maintaining a log listing dates, times, length of pipe installed and ambient temperature during installation.

I. Trench bottoms shall be graded such that each section of pipe shall be placed to the specified depth or elevation with uniform support. When the bottom of the trench has been excavated below the specified depth or elevation it shall be brought to the specified depth or elevation by backfilling with approved pipe zone material. When material at the bottom of the trench is determined to be unsuitable by the Engineer, it shall be removed and the trench backfilled with approved subgrade material or bedding material to the specified depth of excavation.

J. During pipe installation, the trench bottom shall be kept free of frost, frozen earth, or standing water. The Contractor shall maintain the trench in good, stable condition at all times to prevent caving.

K. Precautions shall be taken to prevent flotation of the pipe in the trench.

L. The pipeline may be buried as it is installed, provided all inspection, testing and backfill requirements are met.

M. All areas disturbed by installation of the pipeline shall be restored in accordance with the specification and drawings.

3.2 JOINING METHOD

A. HDPE pipe shall be joined with butt, heat fusion joints as outlined in ASTM D3261 and conform to the Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe, Technical Report TR-33, published by the Plastic Pipe Institute (PPI). All joints shall be made in strict compliance with the manufacturer's recommendations. A factory qualified joining technician as designated by pipe manufacturer or experienced, trained technician shall perform all heat fusion joints in the presence of the Inspector. The Contractor shall install the HDPE pipeline complete, including bends, couplings, valves, and other associated fittings and appurtenances as shown on the drawings or specified herein and make all necessary connections to the lines and grades shown on the Drawings and in accordance with these specifications.

B. The Contractor shall furnish all welding equipment and all construction materials and equipment required for lugs, railings, templates, spiders or other supports and internal bracing as may be required to hold the components firmly within the specified tolerances during welding, concrete placement or backfill placement. The contractor shall also furnish and install all necessary positioning devices, ties, pedestals and supports required for installation. Details of such equipment shall be included in the proposed installation procedure to be submitted to the engineer prior to the start of work.

C. Lengths of pipe shall be assembled into suitable installation lengths by the butt-fusion process. All pipes so joined shall be made from the same class and type of raw material made by the same raw material supplier. Pipe shall be furnished in standard laying lengths not to exceed 50 feet and no shorter than 20 feet. Installation shall be in accordance with the requirements of AWWA C906 unless otherwise noted, and the Manufacturer's instructions. Contractor shall be responsible for correct fitting of all pipeline members and components.

D. The polyethylene flange adapters shall be used at pipe material transitions and other locations as indicated in the drawings. The adapters shall be connected together or to other flanges by using a stainless steel "back-up" ring conforming to ANSI B16.1 and shaped as necessary to suit the outside dimensions of the pipe. Ensure that back up rings are in place prior to joining flange adapter to piping or other components. The flange adapter assemblies shall be connected with corrosion resistant bolts and nuts of Type 316 Stainless Steel as specified in ASTM A726 and ASTM A307. All bolts shall be tightened to the manufacturer's specified torques. Bolts shall be tightened alternatively and evenly. After installation apply a non-oxide grease coating to bolts and nuts.

E. Where indicated, sleeve couplings shall be used to make HDPE joints. When sleeve couplings are used, stainless steel (Type 316), pipe stiffeners shall be inserted inside of each HDPE pipe end as recommended by the manufacture to prevent the pipe from going out of round and to ensure a leak free joint. Sleeve couplings shall be specifically rated for service with HDPE pipe and shall be as specified in the Contract Documents. Sleeve coupling shall only be used where indicated in the plans and in conjunction with an HDPE Pipe Anchor Block.

3.3 PREPARATION

A. Butt-fusion welded joints: Refer to Manufacturers recommended procedures. All joints formed by butt fusion processes shall be completed in strict accordance with the Manufacturers specified procedures, except where specifically called out in the specifications or drawings. Minimum requirements for butt-fusion welded joints are as follows:

1. Pipe ends shall be made clean and square prior to fitting and alignment
2. Care shall be taken to assure a clean work area, free from airborne dust, moisture, or other foreign matter which may contaminate the finished weld.
3. All internal surfaces of the pipe shall be maintained clean following completion of a weld and prior to starting the next joint.
4. All butt-fusion joints shall be water tight under the maximum internal pressure.

3.4 BACKFILL PLACEMENT

A. Pipe zone material shall be placed in accordance with the Drawings. Care shall be taken to ensure that the material is carefully worked and compacted into the area beneath and around

the pipe to provide continuous support to the pipe. Material shall be properly haunched to provide support. Care shall be taken to avoid movement of the pipe during placement and compaction of the bedding material. Pipe bedding shall be placed to the limits shown on the drawings.

B. Trench backfill shall be placed in accordance with the Drawings.

C. No construction vehicles or ride-on mechanical compaction equipment shall be permitted to travel over the pipe until a minimum of 2 feet of trench backfill is placed above the top of the pipe.

3.5 CONNECTION TO EXISTING

A. Mechanical connections of the polyethylene pipe to auxiliary equipment such as valves, pumps and tanks shall be through flanged connections which shall consists of the following:
   1. A polyethylene flange adapter shall be thermally butt-fused to the stub end of the pipe.
   2. A Type 316 stainless steel back up ring shall mate with the polyethylene flange adapter.
   3. Type 316 stainless steel bolts and nuts shall be used to complete the connection.
   4. Flange connections shall be provided with a full-face neoprene gasket.

B. All transitions from HDPE pipe to ductile iron or PVC shall be made per the approval of Engineer and per the HDPE pipe manufacturer's recommendations and specifications. A molded flange connector adapter with a back-up ring assembly shall be used for pipe type transitions. Ductile iron back-up rings shall mate with cast iron flanges per ANSI B16.1. A type 316 stainless steel back-up ring shall mate with a type 316 stainless steel flange per ANSI B16.1 and shall be used in all buried applications.
   1. Transition from HDPE to ductile iron fittings and valves shall be approved by Engineer before installation.
   2. No solid sleeves couplings shall be allowed between such material transitions.
   3. The pipe supplier must certify compliance with the above requirements

C. Prior to making connections to any existing structure or pipe, ensure that new pipe has had the time required to acclimate to the buried conditions. Make the appropriate adjustments required by the thermal expansion and contraction properties of HDPE materials before connecting to any dissimilar material or structure.

3.6 FIELD QUALITY CONTROL

A. On days butt fusions are to be made, the first fusion shall be a trial fusion in the presence of the Inspector. The following shall apply:
   1. Heating plates shall be inspected for cuts and scrapes. The plate temperature shall be measured at various locations to ensure proper heating/melting per manufacturer's recommendations and as approved by the Inspector.
   2. The fusion or test section shall be cut out after cooling completely for inspection.
   3. The test section shall be 12" or 30 times (minimum) the wall thickness in length and 1" or 1.5 times the wall thickness in width (minimum).

4. The joint shall be visually inspected as to continuity of "beads" from the melted material, and for assurance of "cold joint" prevention (i.e. – joint shall have visible molded material between walls of (pipe). Joint spacing between the walls of the two ends shall be a minimum of 1/16" to a maximum 3/16".

3.7 TOLERANCES

A. The centerline of the pipe shall not deviate from a straight line drawn between the centers of the openings at the ends of the pipe by more than 1/16-in per foot of length. If a piece of pipe fails to meet this requirement check for straightness, it shall be rejected and removed from the site. Laying instructions of the manufacturer shall be explicitly followed. Good alignment shall be preserved during installation. Deflection of the pipe shall occur only at those places on design drawings and as approved by the Engineer. Fittings, in addition to those shown on the Drawings, shall be used only if necessary or required by the Engineer.

3.8 CLEANING

A. Do not allow dirt, grease, mud, groundwater, tools, equipment and all other foreign matter to enter the pipe at any point during construction.

B. All pipes shall be completely flushed at a rate with water velocities no less than 4.0 feet per second for pipes up to 12 inches in diameter and 3.0 feet per second for all other pipes. For large diameter pipes, alternate methods, including pigging, of cleaning the pipe may be proposed by the Contractor, subject to the approval of the Engineer, provided proposed method will provide a clean pipe equivalent to flushing as determined by the Engineer.

C. No debris, rubbish, dirt, rocks, or other foreign material shall be permitted to enter downstream sections of the pipeline or system.

D. Furnish, install and permanently remove all cross-connections, piping, valving, ports, etc required to complete the cleaning process. Obtain approval of the Engineer prior to adding any components to the pipeline.

3.9 HYDROSTATIC PRESSURE TESTING

A. Hydrostatic pressure testing shall be conducted per the requirements of ASTM F 2164 and these specifications.

B. All HDPE mains shall be field-tested. Contractor shall supply all labor, equipment, material, gages, pumps, plugs, meters and incidentals required for testing. Each main shall be pressure tested upon completion of the pipe laying and backfilling operations, including placement of any required temporary roadway surfacing.

C. Submit a plan for testing, including schedule, method for water conveyance, control, and disposal, to the Engineer for review at least 10 days before starting the test and notify the Engineer a minimum of 48 hours prior to test

D. The maximum test pressure shall be as indicated in the Drawings but shall not exceed 150 percent of the maximum working pressure of the pipe or the design pressure of any component on the pipe, whichever is less..

E. The test temperature of the piping and the test liquid (water) shall not exceed 73 degrees F. or the temperature related to the pressure rating of the pipe as reported by the manufacturer.

F. Test equipment, preparations and procedures shall implicitly follow the requirements of ASTM F 2164 and the Manufacturer's recommendations.

G. In preparing for test, fill line slowly with water. Maintain flow velocity less than 2 feet per second or less than the capacity of any air release devices use to expel trapped air, whichever is less.

H. Expel air completely from the line during filling and again before applying test pressure. Air shall be expelled by means of taps at points of highest elevation. Any taps installed solely for the purpose of releasing trapped air shall be permanently capped at the conclusion of the test.

I. Once all air is expelled and all testing equipment and pipeline components are adequately braced, gradually increase the pressure in the pipeline to the required maximum test pressure. Hold test pressure for four hours adding make-up water as required to maintain the noted maximum test pressure.

J. After the four hour equalization period, reduce pressure in the pipeline by 10 psi to the test pressure and monitor the pressure for 1 hour. Do not increase the pressure or add make-up water during this time.

K. During and after the one-hour test period, observe all components, joints, fittings, and appurtenances of the pipeline for visible signs of leakage. Any visible signs of leakage indicate a failed test, all such leaks shall be repaired and pipeline retested before pipeline will be accepted. If any visible signs of leakage in any butt-fusion joints in the pipe are noted, immediately stop the test and carefully release the test pressure. Repair the noted leaks and restart test procedure from beginning.

L. A successful hydrostatic pressure test will be indicated by no visible signs of leakage and a steady pipeline pressure within 5 psi of the test pressure throughout the one hour test period without increasing the pressure or the addition of make-up water.

M. Upon completion of the test, the pressure shall be bled off from a location other than the point where the pressure is monitored. The pressure drop shall be witnessed by the Engineer at the point where the pressure is being monitored and shall show on the recorded pressure read-out submitted to the Engineer.

N. Repair and/or replace any failed pipeline sections, components, fittings, valves or other appurtenances to the satisfaction of the Engineer and at no additional expense to the Owner.

3.10 LOW PRESSURE AIR TESTING

A. HDPE pipelines intended for use as air ducts shall be tested for leakage prior to placing the pipe in service. Air test shall not be used for acceptance of any HDPE pipeline except those indicated herein or in the Drawings. Furnish, install and completely remove all fittings, branches, plugs, valves and other appurtenances required to complete the testing process.

B. Prior to beginning air test, HDPE pipeline shall be isolated from pipeline components not rated for the air pressures called for in the test.

C. Low pressure air testing shall be completed per the requirements of ASTM F1417 as given in Section 33 08 00 – Gravity Piping Testing and Inspection.

D. Pipeline shall be inspected for all visible infiltration leaks as evidenced by infiltrating groundwater. Leaks shall be located and repaired at no additional cost to the Owner and to the satisfaction of the Engineer.

3.11 MANDREL TESTING

A. After successful completion of hydrostatic test, mandrel test all buried HDPE piping.

B. Mandrel configuration: Rigid with circular cross-section with a diameter of not less than 95% of the average inside diameter of the pipeline with a length of circular proportion equal to the nominal diameter of the pipeline.

C. Mandrel pulling method shall be by hand, rope or as directed by the Engineer.

END OF SECTION

SECTION 33 05 07
POLYVINYL CHLORIDE (PVC) PIPE (AWWA C900 AND C905, MODIFIED)

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide polyvinyl chloride (PVC) pressure pipe, complete in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards:

ANSI/AWWA C104/A21.5	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
ANSI/AWWA C105/A21.5	Polyethylene Encasement for Ductile Iron Pipe
ANSI/AWWA C110/A21.10	Ductile-Iron and Gray-Iron Fittings 3-in Through 48-in for Water and Other Liquids
ANSI/AWWA C111/A21.11	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
ANSI/AWWA C600	Installation of Ductile-Iron Water Mains and Appurtenances
ANSI/AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe 4-in Through 12-in for Water Distribution
ANSI/AWWA C905	Polyvinyl Chloride (PVC) Pressure Pipe 14-in Through 48-in for Water Distribution
ASTM D 2584	Test Method for Ignition Loss of Cured Reinforced Resins
PPI Technical Report TR 3/4	Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials
AWWA Manual M23	PVC Pipe - Design and Installation

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings: The Contractor shall submit shop drawings of pipe, fittings, and appurtenances in accordance with the requirements in Section 01 33 20 – Contractor Submittals. Manufacturer's literature for metallic locating tape.
   1. Showing dimensions and details of pipe joint fittings, fitting specials, valves and appurtenances.
   2. Detailed layout, spool or fabrication drawings showing pipe spools, spacers, adapters, connectors, fittings and pipe supports not indicated in the Contract Documents.

3. Manufacturer's product data and samples of all materials proposed for use on the work.

B. Certifications: A certified affidavit of compliance for pipe and other products or materials under this Section.

C. Test Reports:
1. Hydrostatic proof test reports.
2. Sustained pressure test reports.
3. Burst strength test reports.

D. The Contractor shall be responsible for performing and paying for sampling and testing as necessary for the certifications.

E. Owner's Manual
1. Manufacturer's technical data and installation instructions.
2. Manufacturer's certificates of compliance indicating that all materials provided under this Section meet the requirements of the Contract Documents.

1.4 QUALITY ASSURANCE

A. Inspection: Pipe shall be subject to inspection at the place of manufacture.

B. During manufacture of the pipe, the Engineer shall be given access to all areas where manufacturing is in process and shall be permitted to make all inspections necessary to confirm compliance with the Specifications.

C. Tests: Materials used in manufacture of the pipe shall be tested in accordance with the requirements of this Section and the referenced standards, as applicable.

D. The Contractor shall perform said material tests. The Engineer shall have the right to witness testing; provided that the Contractor's schedule is not delayed for the convenience of the Engineer.

E. In addition to those tests specifically required, the Engineer may request additional samples of any material for testing by the Owner. The additional samples shall be furnished as a part of the Work.

1.5 INSPECTION

A. All pipe may be subject to inspection at the place of manufacture in accordance with the provisions of the referenced standards as supplemented by the requirements herein. The Contractor shall notify the District in writing of the manufacturing starting date not less than 14 calendar days prior to the start of any phase of the pipe manufacture.

B. During the manufacture of the pipe, the District shall be given access to all areas where manufacturing is in process and shall be permitted to make all inspections necessary to confirm compliance with the Specifications.

1.6 SOURCE QUALITY CONTROL

A. Except as modified herein, pipe shall be tested in accordance with the requirements of this Section and AWWA C900 or C905, as applicable.
   1. The Contractor shall perform said material tests in accordance with the requirements of the Contract Documents. The Owner shall have the right to witness all testing conducted by the Contractor; provided, that the Contractor's schedule will not be delayed for the convenience of the Owner.
   2. All expenses incurred in obtaining samples for testing shall be borne by the Contractor at no increased cost to the Owner.
   3. In addition to those tests specifically required, the Owner may request additional samples of any material for testing by the Owner. The additional samples shall be furnished at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. PVC pressure pipe (4-inch through 12-inch) shall conform to the applicable requirements of ANSI/AWWA C900 subject to additional requirements herein.

B. PVC pressure pipe (14-inch through 48-inch) shall conform to the applicable requirements of ANSI/AWWA C905 subject to additional requirements herein.

C. Each piece of pipe and fitting shall be clearly labeled to identify its size, pressure class and manufacture date.

2.2 PIPE DESIGN CRITERIA

A. General: PVC pressure pipe shall be designed in accordance with the requirements of ANSI/AWWA C900 and ANSI/AWWA C905.

B. Polyvinyl Chloride (PVC) pipe shall have outside diameter dimensions conforming to cast iron pipe and shall be the diameter and class indicated on the plans. The pipe shall meet the pressure class requirements indicated on the drawings, and shall meet the requirements of Table 2 of AWWA C900 or C905 as applicable.

C. PVC pipe shall be provided in standard 20 foot lengths, unless otherwise specified, detailed or required on the approved plans. Shorter lengths, up to 10 feet, will be permitted when authorized by the Engineer. Field cut lengths of pipe used as closures may not be shorter than 2 feet in length, and must be approved by the Engineer.

2.3 PIPE

A. The pipe shall be of the diameter and pressure class specified or shown, shall be furnished complete with rubber gaskets, and all specials and fittings shall be provided as required in the Contract Documents. Unless otherwise noted, diameters shown in the Contract Documents shall refer to Cast-Iron Pipe Equivalent Outside Diameters (CIOD), conforming to the requirements of AWWA C900 or C905 as appropriate.

B. Additives and Fillers: Unless otherwise allowed in alternate qualification procedures of PPI-TR3, compounds which have a Hydrostatic Design Basis (HDB) of 4000 psi at 73.4 degrees F and for water shall not contain additives and fillers that exceed the recommended values in Table 1, Part Y of PPI-TR3 (e.g., allowable content range for calcium carbonate is 0.0-5.0 parts per hundred of resin). If requested by the Engineer, the additive and filler content shall be determined using the pyrolysis method as specified in ASTM D 2584.

C. Color: Pipe for use in potable or culinary water systems, or directly attached to potable or culinary water systems shall be white or blue. Pipe used in irrigation, reuse, utility water or any other non-potable use shall be purple.

D. Joints: Except where specifically noted or where designated as "fusible PVC," joints for buried PVC pipe shall be either an integral bell manufactured on the pipe or a separate coupling both employing a rubber ring joint. The bell and coupling shall be the same thickness as of the pipe barrel, or greater thickness. The sealing ring groove in the coupling shall be of the same design as the groove in cast iron fittings and valves available from local water works supply distributors. No restrained joint PVC pipe will be allowed. When the spigot end of pipe is to be inserted into a mechanical joint fitting, the beveled end of the pipe shall be removed prior to insertion. Solvent weld joints are not permitted.

E. Joint shall be sealed with an elastomeric gasket meeting the requirements of ASTM F 477 and ASTM D3139. Gaskets and lubricants shall be made from materials that are compatible with the plastic material and with each other when used together. They shall not support the growth of bacteria and shall not adversely affect the potable qualities of the water that is to be transported. One elastomeric gasket shall be furnished with each length of bell-end pipe.

F. Joint Deflection: Deflection at the joint shall not exceed 1.5 degrees or the maximum deflection recommended by the manufacturer. No deflection of the joint shall be allowed for joints which are over-belled or not belled to the stop mark.

2.4 FITTINGS

A. Fittings shall be ductile iron fittings meeting the requirements of Section 33 41 05 – Ductile Iron Pipe and of AWWA C110 and/or AWWA C153. Fittings shall be wrapped in polyethylene encasement per AWWA C-105 and all hardware shall be coated with a non-oxide grease.

B. Where fabricated PVC fittings are specifically required:
   1. Fittings (4-inch through 12-inch) shall conform to the applicable requirements of ANSI/AWWA C900 subject to additional requirements herein.
   2. Fittings (14-inch through 48-inch) shall conform to the applicable requirements of ANSI/AWWA C905 subject to additional requirements herein. All fabricated PVC fittings 14-inch and larger shall include fiberglass reinforcement permanently bonded to the outside surfaces of the fitting.

C. All ductile iron fittings shall be lined in accordance with Section 33 41 05 – Ductile Iron Pipe. Fittings shall be cement-mortar lined ductile, coated with a bituminous material and shall conform to the requirements of AWWA Standard C110 and C111 with a minimum rated working pressure of 250 psi. The cement lining shall conform to the requirements of AWWA Standard C104

D. Each fitting shall be clearly labeled to identify its size and pressure class.

E. All fittings and valves shall be restrained against thrust forces by concrete thrust blocks furnished and installed as indicated in the Drawings.

2.5 TRACER WIRE

A. Tracer wire shall be N0. 12 AWG copper wire, PVC jacketed for underground services.

2.6 SERVICE SADDLES

A. Bronze bodied saddles with double bronze straps or full circle body clamp double bolted to each side of the saddle shall be used on pipe sizes 4 inch through 12 inch. The saddle body shall be manufactured from cast bronze in accordance with ASTM B62 or B584 and AWWA C800. The single strap shall have double bolts on each end of the strap to connect it to the bronze saddle. The ears of the strap shall turn inward and rest against the inside of the strap. The gasket shall be Buna N. The saddle shall be threaded with 1 inch or 2 inch iron pipe threads.

PART 3 - EXECUTION

3.1 GENERAL

A. Laying, jointing, testing for defects and for leakage shall be performed in the presence of the Engineer, and shall be subject to approval before acceptance. Material found to have defects will be rejected and the Contractor shall promptly remove such defective materials from the Site.

B. Installation shall conform to the requirements of AWWA M23, instructions furnished by the pipe manufacturer, and to the supplementary requirements herein. Wherever the provisions of this Section and the aforementioned requirements are in conflict, the more stringent provision shall apply.

C. The Contractor shall install all the pipe closure sections, fittings, valves and appurtenances shown on the approved plans, including bolts, nuts, gaskets and joining materials.

D. The Contractor shall excavate sufficiently in advance of pipe laying operations to enable the alignment and profile to be revised to clear existing utilities and to align with existing connection points.

E. PVC pipe which has been gouged shall not be used. PVC pipe which has received minor scratches during handling may be used solely at the discretion of the Engineer.

F. The Contractor shall maintain the interior of the pipe clean, sanitary and free from foreign materials. At all times when the work of installing pipe is not in progress, all openings into the pipe and the ends of the pipe in the trenches shall be kept tightly closed to prevent the entrance of animals and foreign materials. To prevent unwanted water intrusion, open ends of pipe shall be closed temporarily with a watertight bulkhead.

G. Do not install any pipe contaminated with a petroleum product (inside or outside).

H. Do not install any pipe that shows evidence of exposure to sunlight, age, surface deterioration, or other physical damage. The decision of the Engineer shall be final as to the acceptability of the pipe to be installed.

3.2 HANDLING AND STORAGE

A. Handling: Pipe, fittings and accessories shall be carefully inspected before and after installation and those found defective shall be rejected. Pipe and fittings shall be free from fins and burrs. Before being placed in position, pipe, fittings, and accessories shall be cleaned, and shall be maintained in a clean condition. Proper facilities shall be provided for lowering sections of pipe into trenches. Under no circumstances shall pipe, fittings or any other material be dropped or dumped into trenches. The pipe shall be hoisted with mechanical equipment using a cloth belt sling or a continuous fiber rope which avoids scratching the pipe. A chain is not permitted. Pipes up to 6 inches in diameter can be lifted by hand.

B. Storage: Pipe should be stored, if possible, at the Site in unit packages provided by the manufacturer. Caution should be exercised to avoid compression damage or deformation to bell ends of the pipe. Pipe shall be supported uniformly while being stored in such a way as to prevent sagging or bending and be protected from exposure to direct sunlight by covering with an opaque material while permitting adequate air circulation above and around the pipe. Gaskets should be stored in a cool, dark place out of the direct rays of the sun, preferably in original cartons.

3.3 TRENCHING AND BACKFILL

A. Trench excavation and backfill shall conform to the requirements of Section 31 23 00 – Earthwork. Care shall be taken to ensure that pipe zone material is compacted and in full contact with the haunches of the pipe and that the pipe is fully supported.

3.4 INSTALLATION

A. Bell-and-spigot pipe shall be laid with the bell end pointing in the direction of laying. Pipe shall be graded in straight lines, taking care to avoid the formation of any dips or low points. Pipe shall not be laid when the conditions of trench or weather are unsuitable. At the end of each day's work, open ends of pipe shall be closed temporarily with wood blocks or bulkheads.

B. Pipe shall be supported at its proper elevation and grade, care being taken to secure firm and uniform support. Wood support blocking will not be permitted. The full length of each section of pipe and fittings shall rest solidly on the pipe bed, with recessed excavation to accommodate bells, joints, and couplings. Anchors and supports shall be provided where indicated and where necessary for fastening work into place. Fittings shall be independently supported.

C. Short lengths of pipe shall be used in and out of each rigid joint or rigid structure. Piping that does not allow sufficient space for proper installation of jointing material shall be replaced by one of proper dimensions. Blocking or wedging between bells and spigots will not be permitted.

D. Joints shall be installed according to manufacturer's recommendations. Trenches shall be kept free of water until joints have been properly made. The maximum combined deflection at any coupling shall be in accordance with the manufacturer's recommendations.

E. Pipe shall be cut by means of saws, power driven abrasive wheels, or pipe cutters, which will produce a square cut. No wedge-type roller cutters will be permitted. After cutting, the end of the pipe shall be beveled using a beveling tool, portable type sander, or abrasive disc.

F. Pipe end shall be secure at all times and care shall be taken to prevent any foreign object, dirt, rocks, debris, rubbish, tools, etc from entering the pipe. Pipe end shall be capped at the end of each days laying operations. Provided required minimum separation from adjacent utilities are satisfied.

G. Install PVC pipe such that the indelible identification strip markings on each pipe section are continuously aligned for the total length of the pipeline being installed. Orient the strip marking upward to the 12 o'clock position (top) of the trench opening.

H. Assemble the pipe joint using the lubricant supplied by the manufacturer. Ensure lubricant is NSF certified for use in potable water systems. Insert the spigot end into the bell or coupling to the proper insertion mark. Check that the elastomeric ring has not left the groove during assembly by passing a feeler gauge around the completed joint.

I. Tapping saddles shall be installed a minimum of 5 feet from the edge of the saddle to any pipe joint or other saddle. Multiple taps of 6 inches or larger shall not be made in the same length of pipe without the approval of the Engineer.

3.5 INSTALLATION OF METALLIC LOCATING TAPE

A. Polyvinyl chloride pipelines shall be provided with a metallic locating tape laid along the centerline of the pipe trench at a depth of 18 inches below finished grade **OR** above top of pipe. The Contractor shall furnish manufacturer's literature, completely describing the tape proposed to be furnished. No tape shall be used prior to receipt of written approval of the Engineer.

3.6 INSTALLATION OF LOCATOR WIRE

A. Polyvinyl chloride pipelines shall be provided with locator wire secured to the pipe with surface connections provided at all valve boxes and hydrants and as required to maintain a maximum distance between connections of no greater than 500 feet. Tracer wire shall be laid along the top of the pipe and held in place with ties or hitches. The ties or hitches shall be spaced not more than 10 feet apart. The copper wire is to be used in the future as a means of locating the pipe with an electronic-type pipe locator.

3.7 FIELD TESTING AND DISINFECTION

A. Field testing shall conform to the requirements of Section 33 13 00 – Water Pipeline Testing and Disinfection as applicable.

END OF SECTION

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SECTION 33 05 16
PRECAST CONCRETE MANHOLES AND VAULTS

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide precast concrete manholes, catch basins, drop inlets, potable water vaults; meter vaults, and other pre-cast concrete structures complete and in place, in accordance with the Contract Documents.

1.2 RELATED SECTIONS

A. Section 03 30 00 – Cast-in-place Concrete

B. Section 31 23 00 – Earthwork

1.3 SPECIFICATIONS, CODES AND STANDARDS

A. Commercial Standards

ASTM A 48	Gray Iron Castings
ASTM C 150	Portland Cement
ASTM C 443	Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM C 478	Precast Reinforced Concrete Manhole Sections
ASTM C 877	Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
ASTM C 923	Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
ASTM C 990	Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

1.4 CONTRACTOR SUBMITTALS

A. General: Furnish submittals in accordance with Section 01 33 20 - Contractor Submittals.

B. Shop Drawings:
1. Show dimensions, locations, lifting inserts, reinforcement, and joints.
2. Structural design calculations for vaults and boxes shall be stamped and signed by a structural engineer registered in the state of Utah.

C. Manufacturer's Certification for Manholes and Vaults: Written certification that the structure complies with the requirements of this Section.

D. Manufacturer's Test Results: Pull out force for manhole steps.

1.5 QUALITY ASSURANCE

A. Inspection: After installation, the Contractor shall demonstrate that manholes and vaults have been properly installed, level, with water-tight joints, at the correct elevations and orientations, and that the backfilling has been carried out in accordance with the Contract Documents.

B. Any precast concrete which arrives on site with voids, cracked, or damaged, or is cracked or damaged during installation shall be cause for rejection. Contractor shall remove precast section(s) from the project site and replace with new undamaged sections at no additional cost to OWNER.

1.6 DELIVERY, STORAGE AND HANDLING

A. Handle precast units in positions consistent with their shape and design. Lift and support only from the support points indicated on the shop drawings.

B. Embedded Lifting or Handling Devices: Capable of supporting units in positions anticipated during manufacturing, storage, transportation and installation.

C. Block and brace units during storage. Provide lateral bracing which is sufficient to prevent bowing and/or warping and will not inhibit curing of the exposed surfaces.

PART 2 - PRODUCTS

2.1 MANHOLES

A. The Contractor shall provide precast manhole sections and conical sections conforming to ASTM C 478 and the requirements of this Section. Cement used in manufacturing the manholes shall be Type II modified portland cement in accordance with ASTM C 150

1. Manholes, adjusting rings, grout channels and other concrete components of manholes and vaults used in raw sewage, plant drain, drain, or other potentially corrosive environments shall be constructed of polymer concrete that is resistant to hydrogen sulfide corrosion. Shop drawings for these manholes shall clearly indicate that the polymer concrete is used and each component shall be clearly marked for ready identification in the field of structure containing polymer.

B. Adjusting rings shall be standard items from the manufacturer of the manhole sections. Minimum wall thickness of rings shall be 4-inches if steel reinforced and 6-inches if not reinforced.

C. Axial length of sections shall be selected to provide the correct total height with the fewest joints. Joints shall be minimized and shall be located as close as possible to the top of the structure to help minimize opportunity for groundwater infiltration.

D. Conical sections shall have an eccentric shape and shall be designed to support cast iron frames and covers under an H-20 loading, unless indicated otherwise.

E. Design Criteria: Manhole walls, transitions, conical sections, and base shall be designed per ASTM C 478 for the depths indicated and the following:
   1. AASHTO H-20 loading applied to the cover when required in the design drawings.
   2. Unit weight of soil of 120 pcf located above all portions of the manhole.
   3. Lateral soil pressure based on saturated soil producing 100 pcf acting on an empty manhole.
   4. Internal fluid pressure based on unit weight of 63 pcf with manhole filled from invert to cover with no balancing external soil pressure.
   5. External pressures and uplift forces due to groundwater elevations 2 feet below finish grade.
   6. Dead load of manhole sections fully supported by the base and transition.
   7. Additional reinforcing steel in walls to transfer stresses at openings.
   8. The minimum clear distance between the edges of any 2 wall penetrations shall be 12-inches or one-half of the diameter of the smaller penetration, whichever is greater.

F. Joints shall have lipped male/female ends which shall provide uniform and continuous interior wall surfaces and shall be watertight. All joints (including joints between adjusting rings and manhole structure, other adjusting rings and frame and cover) shall be sealed with a preformed flexible sealant conforming to ASTM C 990.

G. Raw Sewage, Plant Drain, drain manholes, plant effluent and all vaults shall also have each joint wrapped with an external joint sealant meeting ASTM C 877. Concrete for base and channel formation shall be 4000 psi concrete conforming to Section 03 30 00 – Cast-In-Place Concrete.

H. Barrel section to sewer pipe (Raw sewage, plant drain, drain, and plant effluent) connections shall be sealed with flexible, resilient connectors complying with ASTM C 923 and appropriate for the pipe material being used. Mechanical devices shall be stainless steel.

I. Manhole steps shall be comprised of 1/2-inch grade 60 steel reinforcement rod encased in polypropylene copolymer plastic. Steps shall have tread width of 14-inches. Furnish test results demonstrating step capability to resist a pull out force of 2200 pounds.

J. Manhole riser sections shall be greater than 12 inches in height.

K. Manhole Manufacturers, or Equal
   1. AMCOR Precast, Ogden, Ut
   2. Geneva Pipe, Orem, Ut

2.2 FRAMES AND COVERS

A. Castings: Castings for manhole frames, covers, and grates shall be non-rocking with machined flat bearing surfaces, and shall conform to the requirements of ASTM A 48, Class 30. Unless otherwise indicated, cast iron covers and frames shall be heavy traffic type, 30 inches in diameter. Covers shall have cleated surfaces with pick holes and shall be ventilated in improved areas and have a solid lid design in landscape or native areas.

B. Manhole covers shall be with embossed with lettering saying "Sewer", "Storm Sewer", or "Water". Manhole covers on Plant Drain or Raw Sewage lines shall be molded with "Magna Water District" imprinted on the lid.

C. All frames and covers shall be designed for H-20 traffic loading. Grates and curb inlets in traffic areas shall be designed for H-20 traffic loading.

D. Castings Manufacturers, or Equal
1. D & L Supply
2. Neenah Foundry Co.
3. Olympic Foundry

2.3 VAULTS

A. The Contractor shall provide precast vaults designed for the indicated applications and of the sizes indicated.

B. The minimum structural member thickness for vaults shall be 5-inches. Cement shall be Type V or Type II modified portland cement as specified in ASTM C 150. The minimum 28-day concrete compressive strength shall be 4,000 psi. All reinforcing steel shall be embedded in the concrete with a minimum clear cover as recommended by ACI 318.

C. Design Loading: Vaults in areas subject to vehicular traffic shall be designed for H-20 traffic loading. Vaults in other areas shall be designed for a vertical live load of 300 psf. Lateral loads on vaults in all areas shall be calculated from:
1. L = 90 h, plus surcharge of 240 psf in areas of vehicular traffic
2. Where L = loading in psf
3. h = depth of fill in feet.

D. Design loading shall also take into account the lateral and uplift pressure resulting from a groundwater elevation 2 feet below existing grade.

E. Where joints are designed in pre-cast concrete vaults, such joints shall be interlocking to secure proper alignment between members and prevent migration of soil through the joint. Structural sections at joints shall be sized sufficiently to reinforce the section against localized distress during transportation and handling and against excess contact bearing pressures through the joint. All openings through the precast structure shall be reinforced to transfer loads.
1. Joints shall be sealed watertight. All joints (including joints between adjusting rings and manhole structure, other adjusting rings and frame and cover) shall be sealed with a preformed flexible sealant conforming to ASTM C 990. In addition, all joints shall be wrapped with an external joint sealant meeting ASTM C 877.

F. Where openings for access to the vault are required, the full clear space opening indicated shall be provided, without obstructions from brackets or supports. For large openings where brackets or supports are designed to protrude into the opening for support of required covers, such brackets or supports shall be designed to be easily removed and replaced with a minimum of effort and without cutting or welding.

G. Covers for access openings shall be provided. Frames for covers shall be fabricated from aluminum, and shall be integrally cast into the vault concrete sections. All covers shall be tight fitting to prevent the entrance of dirt and debris. Where edge seams are permitted, no gaps greater than 1/16-inch between edges will be accepted. All covers, except round, heavy-weight, cast iron manhole covers, shall have securing mechanisms to hold the covers firmly in place against the effects of repetitious live loads such as pedestrian or vehicle traffic.

H. Where penetrations of the pre-cast concrete vaults are required for piping, conduit, or ducts, such penetrations shall be accommodated through pre-cast openings or wall sleeves, as indicated. Storm drain structures may also use thin-wall knock-out sections. All openings for penetrations shall be smooth and free of surface irregularities and without exposed steel reinforcing. With the exception of vaults on pressurized water system, vaults need not be designed to resist thrust from piping passing through the vault.

I. Lifting holes shall be plugged with a precast concrete plug sealed with a non-shrink grout.

J. Vault Manufacturers, or Equal
   1. AMCOR Precast, Ogden, Ut
   2. Geneva Pipe, Orem, Ut

2.4 FABRICATION

A. Maintain plant records and quality control program during fabrication of structural precast concrete sections. Make all quality control records available to ENGINEER upon request.

B. Use molds that are rigid, and constructed of material that will result in uniform finished surfaces.

C. If self consolidating concrete is not used, thoroughly vibrate concrete to ensure proper consolidation, elimination of cold joints, and to minimize trapped air on at the concrete surface.

D. Fabricate and provide the required lifting devices which are compatible with embedded components.

E. Ensure reinforcing steel, anchors, inserts, plates, angle and other cast-in items are sufficiently embedded, properly secured, and correctly located. Ensure the reinforcing steel is properly supported to prevent movement or shifting during fabrication. Inadequate concrete cover over reinforcing shall be cause for rejection.

F. Cure precast concrete sections under identical conditions to develop specified concrete quality.

PART 3 - EXECUTION

3.1 GENERAL

A. Prior to accepting manholes on site, ensure that manhole meet the requirements of these specifications, are constructed of the correct materials, and are not cracked or damaged in any other way.

B. Pre-cast concrete sections shall be transported and handled with care in accordance with the manufacturer's written recommendations. Where lifting devices are provided in pre-cast sections, such lifting devices shall be used as intended. Where no lifting devices are provided, the Contractor shall follow the manufacturer's recommendations for lifting procedures to provide proper support during lifting.

C. Buried pre-cast concrete vaults and manholes shall be assembled and placed in excavations on properly compacted soil foundations as indicated. Pre-cast concrete vaults and manholes shall be set to grade, plumb and level, and oriented to provide the required dimensions and clearances from pipes and other structures.

D. Prior to backfilling vaults, pipe and conduit penetrations and other, openings shall be sealed with polyurethane sealant or as indicated in the drawings. With the authorization of the Engineer, grout or a closed-cell flexible insulation may be used as filler material prior to placing a final bed of polyurethane sealant.

3.2 MANHOLES

A. Connect pipe to manhole with flexible connection, as recommended by connection manufacturer. Provide a pipe joint or additional flexible connection 18 inches from the outside of the manhole. Grout around pipe after installation is complete, unless otherwise indicated. All connections shall be watertight.

B. Place top section, cone section or flat slab on top riser section, with the opening positioned over the steps. Top of cone section or flat slab shall be from 10 to 18 inches below finished grade.

C. Install grade rings as required to adjust top of lid and frame to match finish grade elevation. Maximum height of grade rings shall be 12 inches. Maximum number of grade rings shall be two.

D. In paved areas and as indicated in the plans, concrete collars shall be constructed around manhole covers as indicated. Collars shall be of 4000 psi concrete. Collars shall be constructed after pavement has been placed.

E. Steps shall be cast-in-place or vibrated into green concrete.

F. Steps shall be installed 12-inches on centers vertically, not more than 1/2 inch out of plumb. The top step shall be no more then 12-inches below the manhole cover.

G. After manhole base has been completed, furnish and install temporary pipe plugs to seal all interior pipe opening. Plugs shall remain in place until final review and acceptance of completed pipeline. Plugs shall then be removed and shall be property of Contractor.

3.3 QUALITY CONTROL

A. Manholes shall be tested and accepted per the requirements of Section 33 08 00 – Gravity Piping Testing and Inspection.

B. Do not install precast concrete units until concrete has attained its design compressive strength.

END OF SECTION

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SECTION 33 05 19
PRESSURE PIPING TIED JOINT RESTRAINT SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide Chlorinated Polyvinyl Chloride (CPVC) pressure pipe, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 40 05 00 - Piping, General, apply to the WORK of this Section.

PART 2 - PRODUCTS

2.1 PIPE MATERIAL

A. CPVC pipe shall be in accordance with ASTM F 441 - Chlorinated Poly (Vinyl Chloride) (CPVC), Plastic Pipe, Schedules 40, and 80, from all new compounds, meeting the requirements of Class 23447 per ASTM D 1784 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (PVC) Compounds. CPVC pipes shall be Schedule 80 pipe, unless otherwise indicated. CPVC material shall be listed as compliant with NSF Standard 61.

2.2 PIPE JOINTS

A. Pipe joints shall be solvent-welded with solvent cement in accordance with ASTM F 493 - Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings, and with primer in accordance with ASTM F 656 - Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings. Screwed joints which are necessary to match up to threaded valves or fittings shall be made up with appropriate thread sealant, either paste or tape. Flanged joints shall be made with solvent-welded CPVC flanges, drilled to ANSI/ASME B 16.5 - Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated. For CPVC or PVC pipe used in chemical service, solvent welded joints shall be done using IPS Corp Type 724 cement or another cement certified by the manufacturer for chemical service.

2.3 FITTINGS

A. Solvent-Welded Fittings: Solvent-welded fittings shall be Schedule 80 CPVC fittings in accordance with ASTM F 439 - Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

B. Threaded Fittings: Threaded fittings shall be Schedule 80 CPVC fittings in accordance with ASTM F 437 - Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

C. Flanged Fittings: Flanged fittings shall be fabricated Schedule 80 CPVC fittings with 150 lb. flanges to ANSI/ASME B 16.5. Gaskets shall be ANSI 150 lb. full face, 1/8-inch thick Neoprene

for water or wastewater service. Gasket material for chemicals shall be suitable for use with the chemical service.

2.4 COATINGS

A. Outside of CPVC piping and fittings shall be coated to conform to the requirements of Section 09 90 00 – Painting and Coating.

PART 3 - – EXECUTION

3.1 INSTALLATION

A. General: CPVC pipes shall be installed in a neat and workmanlike manner, properly aligned, and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipes shall afford maximum headroom and access to equipment, and where necessary piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. The entire installation shall be acceptable to the ENGINEER. It is recommended that the CONTRACTOR obtain the assistance of the pipe manufacturer's field representative to instruct the pipe fitters in the correct installation and support of all CPVC piping.

B. Supports and Anchors: Piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 40 05 07 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipes shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences. Where piping support is metallic, Contractor shall provide and install unicusion or other acceptable piping protective shield to encompass the entire portion of pipe in contact with the support material.

C. Valves and Unions: Unless otherwise indicated, connections to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection. Valves and flanges attached to CPVC pipe shall be provided with adequate supports.

3.2 PIPE PREPARATION

A. Prior to installation, each pipe length shall be carefully inspected, flushed clean of any debris or dust, and straightened, if not true. Ends of threaded pipes shall be reamed and filed smooth. Pipe fittings shall be equally cleaned before assembly.

3.3 PIPE JOINTS

A. Threaded Joints: Pipe threads shall conform to ASTM F 1498-Taper Pipe Threads 600 for Thermoplastic Pipe and Fittings, and shall be full and cleanly cut with sharp dies or molded. Joints shall be mode with Teflon tape or thread sealant.

B. Solvent-Welded Joints: Solvent-welded joints shall be made with fresh primer and solvent cement on clean, dry pipe ends. The primer and cement cans shall be kept closed at all times

and the joints shall be made up at the recommended ambient temperatures, to the pipe or cement manufacturer's written recommendations. Pipe ends shall be inserted to the full depth of the socket.

C. Flanged Fittings: Flanged joints shall be made with gaskets and Type 316 stainless steel bolts and nuts. Care shall be taken not to over-torque the bolts, in accordance with the manufacturer's written recommendations.

3.4 INSPECTION AND FIELD TESTING

A. Inspection: Finished installations shall be carefully inspected for proper joints and sufficient supports, anchoring, interferences, and damage to pipe, fittings, and coating. Any damages shall be repaired by the Contractor to the satisfaction of the ENGINEER.

B. Field Testing: The CONTRACTOR shall allow adequate time for the solvent cement joints to cure. Curing time shall be per the solvent cement manufacturer's recommendation. Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule for a period of not less than one hour, without exceeding the tolerances listed in the Piping Schedule. CAUTION – DO NOT use air or gas for testing CPVC pipe. Where no pressures are indicated, the pipes shall be subject to 1-1/2 times the maximum working pressure. The CONTRACTOR shall furnish all test equipment, labor, materials, and devices.

C. Leakage shall be determined by loss of pressure. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines plugged or capped as required during the testing procedures.

D. Leaks shall be repaired by the Contractor to the satisfaction of the ENGINEER and the system shall be re-tested as required until no leaks are found.

END OF SECTION

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SECTION 33 08 00
GRAVITY PIPING TESTING AND INSPECTION

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall perform all pipeline flushing and testing, complete, for gravity piping systems or other yard piping systems as required in the Contract Drawings, and as specified herein; in accordance with the requirements of the Contract Documents.

B. The Contractor shall be responsible for providing and conveying flushing water to the point of usage and also for disposal, as required, of water used in the flushing operations.

C. For the purpose of this specification, gravity piping, sewer or gravity sewer piping refers to all pipes with flows that are driven by gravity in an open channel flow condition and convey liquids associated with the treatment plant processes and byproducts (e.g. plant drain, raw sewage, etc).

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards:

ASTM F1417	Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
ASTM C924	Standard Practice for Testing Concrete Pipe Sewer Line by Low-Pressure Air Test Method
ASTM C1244	Standard Test Method for Concrete Sewer Manholes by Negative Air Pressure (Vacuum) Test Prior to Backfill
UNI-B-6	Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

1.3 CONTRACTOR SUBMITTALS

A. The Contractor's proposed plans for testing, and for water conveyance, control, and disposal, shall be submitted in writing. The Contractor shall also submit minimum 48-hour advance written notice of its proposed testing schedule for review and concurrence of the Engineer.

PART 2 - PRODUCTS

2.1 MATERIALS REQUIREMENTS

A. Temporary valves, plugs, bulkheads, and other air pressure testing and water control equipment and materials shall be provided by the Contractor subject to the Engineer's review. No materials shall be used which would be injurious to pipeline structure and future

function. Air test gages shall be laboratory-calibrated test gages and shall be recalibrated by a certified laboratory at the Contractor's expense prior to the leakage test, if required by the Engineer.

PART 3 - EXECUTION

3.1 GENERAL

A. All testing operations shall be performed in the presence of the Engineer.

B. All water required for cleaning and testing of the sewer pipes shall be furnished by the Contractor.

3.2 CLEANING

A. Do not allow dirt, grease, mud, groundwater, tools, equipment and all other foreign matter to enter the pipe at any point during construction.

B. All pipes shall be completely flushed at a rate with water velocities no less than 4.0 feet per second for pipes up to 12 inches in diameter and 3.0 feet per second for all other pipes. For large diameter pipes, alternate methods, including pigging, or cleaning the pipe may be proposed by the Contractor, subject to the approval of the Engineer, provided proposed method will provide a clean pipe equivalent to flushing as determined by the Engineer.

C. No debris, rubbish, dirt, rocks, or other foreign material shall be permitted to enter downstream sections of the pipeline or system.

D. Furnish, install and permanently remove all cross-connections, piping, valving, ports, etc required to complete the cleaning process. Obtain approval of the Engineer prior to adding any components to the pipeline.

3.3 TESTING OF PIPING

A. General: All gravity sewer pipes and service laterals shall be air tested and mainlines shall be checked for deflection, as specified. All manholes, vaults and boxes directly conveying flows shall be tested for leakage, as specified. Manholes and piping shall be tested following backfill placement. All leakage tests shall be completed and approved prior to the placement of permanent surfacing. When leakage exceeds the amount allowed by the Specifications, the Contractor shall locate the leaks and make the necessary repairs or replacements required to eliminate the leakage. Any individually detectable leaks shall be repaired, regardless of the results of the tests.

B. Leakage Tests: Gravity sewer systems shall be tested for leakage as follows:
   1. Air Pressure Test - Gravity sewers shall be air pressure tested in accordance with UNI-B 6 and/or ASTM F1417 as outlined below.
      a. The Contractor shall furnish all materials, equipment and labor for making an air test. Air test equipment shall be approved by the Engineer.
      b. The Contractor may conduct an initial air test of the sewer main line after densification of the backfill but prior to installation of lateral connection

sewers. Such tests will be considered to be for the Contractor's convenience and need not be performed in the presence of the Engineer.

c. Each section of sewer shall be tested between successive manholes by plugging and bracing all openings in the main sewer line and the upper ends of all lateral connection sewers. Prior to any air pressure testing, all pipe plugs shall be checked with a soap solution to detect any air leakage. If any leaks are found, the air pressure shall be released, the leaks eliminated, and the test procedure started over again.

d. Test pressure shall be 4.0 psig, unless groundwater elevation exceeds the invert elevation of the pipe. Where the normal groundwater elevation exceeds the invert elevation of the new pipe, the test pressure shall be adjusted for back pressure created by the groundwater. The new test pressure shall be determined by:

$$P_t = 4.0 + \frac{H}{2.35} \leq 9.0 \text{ psig}$$

e. Where P_t is the new test pressure and H is the difference in feet between the groundwater elevation and the lowest invert elevation of the pipe being tested. In no case shall the test pressure exceed 9.0 psig or the maximum pressure allowed by the pipe manufacturer.

f. After a manhole to manhole reach of pipe has been backfilled and cleaned, and the pneumatic plugs are checked, the plugs shall be placed in the line at each manhole and inflated to manufacturer's recommended inflation pressure. Low pressure air shall be introduced into this sealed line until the internal air pressure reaches test pressure. At least two minutes shall be allowed for the air pressure to stabilize. After the stabilization period minimum pressure (at the beginning of test time shall be test pressure minus 0.5 psig), the air hose from the control panel to the air supply shall be disconnected.

g. For pipe diameters 4"-36", the portion of line being tested shall be termed "Acceptable" if the allocated line pressure decreases less than 1.0 psi in the time shown for the given diameters and lengths in Table 1.

h. For pipe diameters greater than 36", the portion of line being tested shall be termed "Acceptable", if the allocation line pressure decreases less than 0.5 psi in the time shown for the given diameters and lengths in Table 2.

i. Required test times for lines consisting of multiple pipe diameters shall be determined in accordance with UNI-B-6 and or ASTM F1417.

j. If the installation fails to meet these requirements, the Contractor shall determine the source of leakage. He shall perform a leak location test and then repair or replace all defective materials and/or workmanship. This work shall be completed at no additional cost to the Owner.

Table 1
Low Pressure Air Test Times for 1.0 PSig Pressure Drop

Pipe Diameter (in.)	Minimum Time for 1.0 PSIg Pressure Drop (min:sec)	Pipe Length for Minimum Time (ft.)	Test Time for Pipe Length in Excess of Minimum (sec.)
4	03:47	597	.380 L

6	05:40	398	.854 L
8	07:33	298	1.520 L
10	09:27	239	2.374 L
12	11:20	199	3.418 L
15	14:10	159	5.342 L
18	17:00	133	7.692 L
21	19:50	114	10.470 L
24	22:40	99	13.674 L
27	25:30	88	17.306 L
30	28:20	80	21.366 L
33	31:10	72	25.852 L
36	34:00	66	30.768 L

Table 2
Low Pressure Air Test Times for 0.5 PSIg Pressure Drop

Pipe Diameter (in.)	Minimum Time for 0.5 PSIg Pressure Drop (min:sec)	Pipe Length for Minimum Time (ft.)	Test Time for Pipe Length in Excess of Minimum (sec.)
42	19:50	57	20.939 L
48	22:40	50	27.349 L
54	25:30	44	34.614 L
60	28:30	40	42.733 L
66	31:10	36	51.707 L
72	34:00	33	61.535 L
78	36:50	31	72.219 L
84	39:40	28	83.756 L
90	42:30	27	96.149 L
96	45:20	25	

C. Deflection Test: All flexible and semi-rigid main line pipe shall be tested for deflection, joint displacement, or other obstruction by passing a rigid mandrel through the pipe by hand, not less than 30 days after completion of the trench backfill, but prior to permanent surfacing. The mandrel shall be a full circle, solid cylinder, or a rigid, non-adjustable, odd-numbered leg (9 leg minimum) steel cylinder, approved by the Engineer as to design and manufacture. The circular cross section of the mandrel shall have a diameter of at least 95 percent of the specified average inside pipe diameter of the pipe and the minimum length of the circular portion of the mandrel shall be equal to the nominal diameter of the pipe. Obstructions encountered by the mandrel shall be corrected by the Contractor.

D. Video Inspection: After the sewer pipe has been installed and cleaned; and the trench has been backfilled, the sewer pipe shall be visually inspected by video camera to locate defects in the sewer pipe. Video Inspection shall be performed by an independent testing agency acceptable to the Owner. All sewer pipes shall be video inspected.
   1. Notify the Engineer, 48 hours prior to any televised inspections.
   2. The inspection shall be in digital video format, saved to an electronic media and shall be given to the Engineer for review and final records

3. The Contractor shall ensure safe access to each manhole as required by the testing agency.
4. Video equipment shall include a pipe inspection video camera with the following capabilities: panorama tilt, radial viewing, pans plus and minus 75 degrees, rotates 360 degrees, and has optical zoom from 6 or less inches to infinity. Equipment shall produce a high quality, full color video image.
5. Video equipment shall be equipped with a device that can accurately measure the depth of any ponding encountered in the pipe. Measuring device shall be clearly visible in the video image.
6. The video equipment shall have an accurate footage counter accurate to within 1 foot per 500 foot of pipe. Footage shall be continuously displayed on the video at all times.
7. Pipelines shall be cleaned and flushed immediately prior to video inspection. Pipelines that were cleaned and flushed more than 24 hours prior to video inspection shall be cleaned and flushed again. All dirt/debris, including pipe grease, in the line which could cover a defect shall be removed.
8. Jetting of the lines in conjunction with the video inspection is prohibited.
9. If during the video inspection, foreign material which prohibits an acceptable video inspection is discovered the line shall be cleaned and video inspected again.
10. The video camera shall travel through the pipe at a maximum rate of travel of 30 feet per minute. Video shall be continuous for each pipe segment between manholes or other access points.
11. The video camera shall pause at each tee, lateral or other connection and the camera shall be rotated and tilted to provide an image of the branch for inspection. The image shall remain clear and in focus at all times while zooming to the full extent of the camera. The camera operator shall stop at each fitting and change in pipe type and complete a 360 degree view of the fitting at a rate slow enough to identify any defects.
12. Glare shall be avoided and shall not interfere with viewing the pipe segment.
13. Provide DVDs or CDs with labels indicating project number, segment number, date televised, date submitted, starting manhole number, ending manhole number, pipe diameter, pipe length and street name.
14. Lines to be video inspected shall be flushed within 24 hours prior to beginning of inspection.
15. The video inspection shall be used to identify defective construction such as sags, debris, separated joints, etc. Any Work not conforming to the Specifications or Drawings shall be promptly removed, replaced and retested at no cost to the Owner. The Engineer shall make all final determinations if the severity of the defect constitutes failure and requires subsequent removal or repair of the segment in question.
    a. Conditions identified by the video inspection that require removal and replacement or, but are not limited to:
        1) Alignment (Vertical or Horizontal) is outside the specified limits.
        2) Water ponds in any section with depths equal to or greater than 2 times the grade tolerance specified in the Contract Documents.
        3) Pipe section with visible defects, such as: open joints, pinched gaskets, cracked barrels or bells, leaks, or other defects as determined by the Engineer.

3.4 TESTING OF MANHOLES AND OTHER APPURTENANT STRUCTURES

A. Manholes and other structures

1. Vacuum tests shall be conducted on the newly constructed manholes. Preliminary manhole testing may take place following construction after all connections are made, and before backfilling. Test results derived from this test will allow time for necessary repairs to be completed before further construction proceeds and hinders such repairs. Final tests must be performed after the manhole has been backfilled.

B. Procedures

1. Plug all manhole entrances and exits other than the manhole top access using suitably sized pneumatic or mechanical pipeline plugs and follow all manufacturer's recommendations and warnings for proper and safe installation of such plugs. Plugs should be inserted a minimum of 6 inches beyond manhole wall. Make sure such plugs are properly rated for the pressures required for the test. The standard test of 10 inches Hg. (mercury) is equivalent to approximately 5 PSIG (.3 bar) backpressure. Unless such plugs are mechanically restrained, it is recommended that the plugs are used with a minimum two times (2x) safety factor or a minimum of 10 PSIG (0.7 bar) backpressure usage rating.
2. Close vacuum inlet/outlet ball valve and monitor vacuum for specified test period (see table). If vacuum does not drop in excess of 1" Hg., manhole is considered acceptable and the manhole passes the test. If manhole fails the test, complete necessary repairs and repeat test procedures until satisfactory results are obtained.

Minimum Test Times for Various Manhole Diameters

Depth, Feet	Diameter, Inches												
	48	54	60	66	72	78	84	90	96	102	108	114	120
	Time, Seconds												
8	20	23	26	29	33	35	38	41	45	48	51	54	57
10	25	29	33	36	41	44	48	52	56	60	63	67	71
12	30	35	39	43	49	53	57	62	67	71	76	81	85
14	35	41	46	51	57	62	67	72	78	83	89	94	100
16	40	46	52	58	67	70	76	83	89	95	101	108	114
18	45	52	59	65	73	79	86	93	100	107	114	121	128
20	50	53	65	72	81	88	95	103	111	119	126	135	142
22	55	64	72	79	89	97	105	114	122	131	139	148	156
24	59	64	78	87	97	106	114	124	133	143	152	161	170
26	64	75	84	94	105	114	124	134	144	155	164	175	185

28	69	81	91	101	113	123	133	145	155	167	177	188	199
30	74	87	98	108	121	132	143	155	166	178	189	202	213

3. (The values listed above are taken from ASTM Specification C1244-93 "Standard Test Method for Concrete Manholes by the Negative Air Pressure (Vacuum) Test.")
4. Repeat the above test procedure after backfilling manhole for final acceptance test.
5. Manholes shall be watertight. All joints, penetrations, etc., shall be sealed watertight prior to acceptance of manhole.

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SECTION 33 11 11
STEEL PIPE (AWWA C200, MODIFIED)

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide plural component epoxy lined steel pipe coated as specified herein, complete, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards: The following standards are listed for convenience only. All specified standards, whether listed or not, shall apply to the Work.

ANSI/ASTM A 20	General Requirements for Steel Plates for Pressure Vessels
ASTM E 165	Practice for Liquid Penetrant Examination
ASTM A 370	Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A 516	Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ANSI/AWWA C200	Steel Water Pipe 6 In and Larger
ANSI/AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In and Larger - Shop Applied
ANSI/AWWA C206	Field Welding of Steel Water Pipe
ANSI/AWWA C207	Steel Pipe Flanges for Waterworks Service 4 in to 144 in
ANSI/AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
ANSI/AWWA C209	Cold Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
ANSI/AWWA C214	Tape Coating Systems for the Exterior of the Steel Water Pipelines
ANSI/AWWA C215	Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines
ANSI/AWWA C216	Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines

ANSI/AWWA C218	Coating the Exterior of Above Ground Steel Water Pipelines and Fittings
ANSI/AWWA C222	Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings
ANSI/AWWA C602	Cement-Mortar Lining of Water Pipelines 4-In (100 mm) and Larger - In Place
ANSI/ASTM A 36	Carbon Structural Steel
ANSI/ASTM A 283	Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A 570	Steel Sheet and Strip, Carbon, Hot-Rolled Structural Quality
ASTM A 572	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM C 150	Portland Cement
ANSI/AWS D1.1	Structural Welding Code – Steel
API Standard 1104	Welding Pipelines and Related Structures
AWWA M-11	Steel Water Pipe - A Guide for Design and Installation
ASME	Boiler and Pressure Vessel Code

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings: Submit shop drawings of pipe and fittings in accordance with the requirements in Section 01 33 20 – Submittal Procedures, and the following supplemental requirements as applicable. Fittings and specials shall conform to Section 33 11 12 - Steel Pipe Fabricated Specials. Contractor's submittals for steel pipe and specials shall be coordinated between the sections.

B. Fabrication Information

a. Pipe/fitting wall construction details which indicate the type and thickness of cylinder; the position, type, size, and area of reinforcement; manufacturing tolerances; maximum angular joint deflection limitations; and all other pertinent information required for the manufacture and installation of the product.

b. Welded joint details shall be submitted for all joint types, including beveled ends for alignment conformance and deep bell or butt strap joints required for control of temperature stresses.

c. Rubber gasket joint design and details complete with dimensions, tolerances, and performance or test data.

d. Pipe Fabricator's Credentials: Submit the credentials of the pipe manufacturer/fabricator. Credentials shall include reference names, telephone numbers, and descriptions of projects for pipe conforming to

AWWA C200 that is of similar diameter, length, and wall thickness to the pipe in this project. Project description shall include length, diameter, wall thickness, steel metallurgy, location of facility where pipe was manufactured/fabricated, and names of key plant personnel responsible for the manufacturing process. Submit names and qualifications of current plant personnel to be responsible for manufacture of the pipe in this project. To demonstrate ability to meet the schedule requirements of this project, submit project descriptions and manufacturing/fabrication schedules for other currently contracted pipe projects at the Fabricator's plant. The manufacturing / fabrication schedule for the pipe in this project shall be identified on schedule submittals under Section 01 32 16 – Construction Progress Schedule.

e. Manufacturer's Written Quality Assurance/Control Program.

2. Materials: Material lists and steel reinforcement schedules which include and describe all materials to be utilized. Metallurgical test reports for steel proposed for use on the project. Submit chemical and physical test reports from each heat of steel that indicate the steel conforms to the Project Specifications.

3. Line Layout Information
   a. Line layout and marking diagrams compatible with the requirements of AWWA Manual 11 (M-11) and which indicate the specific mark number of each pipe and fitting and the location of each pipe and the direction of each fitting in the completed line. In addition, the line layouts shall include: the pipe station and centerline elevation at all changes in grade or horizontal alignment; the station and centerline elevation to which the bell end of each pipe will be laid; all elements of curves and bends, both in horizontal and vertical alignment. The location of all mitered pipe sections, beveled ends for alignment conformance, and deep bell or butt strap joints for temperature stress control shall be clearly indicated on the diagrams.
   b. Dimensional drawings of all valves, fittings, and appurtenances as specified in Section 40 05 00 – Piping, General.
   c. Drawings showing the location and details of bulkheads for hydrostatic testing of the pipeline, and details for removal of test bulkheads and repair of the lining.
   d. Details and locations of closures for length adjustment, temporary access manways, vents, and weld lead pass holes as indicated and as required for construction convenience.

4. Welding Information
   a. Information regarding location, type, size, and extent of all welds with reference called out for Welding Procedure Specifications (WPS) numbers shall be shown on the shop drawings. The shop drawings shall distinguish between shop and field welds. Shop drawings shall indicate by welding symbols or sketches the details of the welded joints, and the preparation of parent metal required to make them.
   b. Written welding procedures for shop and field welds, including Welding Procedure Specifications (WPS's) and Procedure Qualification Records (PQR's).
   c. Written nondestructive testing procedure specifications, and nondestructive testing personnel qualifications for shop and field welds.

d. Current welder performance qualifications (WPQ's) shall be submitted for each welder used prior to its performing any Work either in the shop or field. Qualification testing shall be as specified in Article 1.4 - Quality Assurance, Paragraph F, in this Section.
e. Submit the credentials of the Contractor's certified welding inspectors (CWI's) and quality control specialist for review prior to starting any welding in the shop or field. The credentials shall include, but not be limited to, American Welding Society QC-1 Certification.
f. Submit all nondestructive testing (NDT) data for each shop-welded and field-welded joint. This data shall include all testing on each weld joint, including re-examination of repaired welds, using radiographic, magnetic particle, dye penetrant examination, ultrasonic, or air test examination methods specified. Test data shall be reviewed and signed by the welding inspector(s).
g. Submit a welder log for field and shop welding. Log shall list all welders to be used for the Work and the types of welds each welder is qualified to perform.
h. Submit a welding map showing the sequence of welds for all field welds.
i. Submit a written weld repair procedure for each type of shop and field weld proposed for use on the Project.
j. Submit a written rod control procedure for shop and field operations demonstrating how the Contractor intends to maintain rods in good condition throughout the Work. The rod control procedure shall also demonstrate how the Contractor intends to ensure that the proper rods are used for each weld.

5. Handling and Support Information: Detail drawings indicating the type, number and other pertinent details of the slings, strutting and other methods proposed for pipe support and handling during manufacturing, transport, and installation. Calculations supporting the handling and support system design shall be submitted. Drawings and calculations shall be sealed by a registered professional engineer.
6. Control of Temperature Stresses
   a. Submit proposed sequencing of events to control temperature stresses in the pipe wall during installation prior to starting of any field welding.
   b. Submit the proposed sequencing of events or special techniques to minimize distortion of the steel as may result from shop welding procedures.
   c. Submit plan for monitoring pipeline temperatures.
7. Field Lining
   a. Submit field lining contractor’s credentials.
   b. Submit a description of lining equipment and personnel to be used.
   c. Submit written procedures for pipe surface preparation, lining application, and curing.
   d. Submit plural component epoxy product.

C. Certifications: Furnish a certified affidavit of compliance for all pipe and other products, materials, or related work provided under this Section, as specified in ANSI/AWWA C200, C205, C602, and C206, respectively, and the following supplemental requirements:
1. Compliance with the additional requirements included in these Contract Documents.
2. Physical and chemical properties of all steel.
3. Hydrostatic test reports.
4. Results of production weld tests.
5. Rubber gasket tests.
6. All materials are NSF approved for use with potable water where applicable.

7. Pipe temperature complies with Specifications prior to pouring pipe zone material, during and between periods of CLSM placement, and prior to and during welding temperature control joints (including supporting data).
8. All welds were performed in conformance with these documents.

D. All expenses incurred in making samples or collecting data for certification of tests shall be borne by the Contractor at no increased cost to the Owner.

1.4 QUALITY ASSURANCE

A. Inspection: All pipe, linings, welds, coatings, and related work shall be subject to inspection at the place of manufacture and/or the place the Work is performed in accordance with the provisions of ANSI/AWWA C200, C205, C206, C602, C209, C214, C215, and C222 as applicable, as supplemented by the requirements herein. Notify the Engineer in writing not less than 14 calendar days prior to the start of any phase of the pipe manufacture, welding, lining, coating, testing, or field operations.

B. Tests: Except as modified herein, all materials used in the manufacture of the pipe shall be tested in accordance with the requirements of ANSI/AWWA C200, C205, C206, and C602, as applicable.
1. After the joint configuration is completed and prior to lining with plural component epoxy, if applicable, each length of pipe of each diameter and pressure class shall be shop-tested and certified to a pressure of at least 75 percent of the minimum yield strength of the pipe steel. Test pressure shall be maintained for a sufficient time to observe the weld seams. There shall be no leaks. Any leaks shall be repaired and the pipe retested.
2. Production weld tests as required in ANSI/AWWA C200, except weld tests shall be conducted on each 5,000 feet of production welds at a minimum, and at least one set of tests per operator per work shift shall be performed.

C. Perform said material tests at no additional cost to the Owner. The Engineer shall have the right to witness all testing conducted by the Contractor; provided, that the Contractor's schedule is not delayed for the convenience of the Engineer.

D. In addition to those tests specifically required, the Engineer may request additional samples of any material including mixed concrete and lining and coating samples for testing by the Owner. The additional samples shall be furnished at no additional cost to the Owner.

E. Welding Procedure Specifications: All welding procedures used to fabricate and install pipe shall be in accordance with the ASME Boiler and Pressure Vessel Code (BPVC) for shop welds and ANSI/AWS D1.1 for field welds. Written welding procedures shall be required for all welds, both shop and field. Welds qualified per the ASME BPVC shall include Supplementary Essential Variables for notch-tough welding. All provisions of ANSI/AWS D1.1 pertaining to notch-tough welding shall apply.

F. Welder Performance Qualifications: All welding shall be done by skilled welders, welding operators, and tackers who have had adequate experience in the methods and materials to be used. Welders shall be qualified by the Contractor under the provisions of ASME BPVC for

shop welds and ANSI/AWS D1.1 for field welds. Furnish all material and bear the expense of qualifying welders.

G. Shop Nondestructive Testing: Nondestructive testing shall be performed for various weld categories as specified below. Testing shall include submitting written documentation of procedures per Section V, and acceptance criteria shall be in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.
   1. Butt Joint Welds: Spot radiographically examine pipe in accordance with Paragraph UW-52 of the ASME Boiler and Pressure Vessel Code Section VIII, Division 1. If, in the opinion of the Engineer, the butt joint welds cannot readily be radiographed, they shall be 100 percent ultrasonically examined.
   2. Fillet Welds: 100 percent examine all fillet welds using the magnetic particle inspection method.
   3. Groove Welds: 100 percent ultrasonically examine all groove welds that cannot be readily radiographically spot examined.
   4. All Welds: Certified welding inspector shall 100 percent visually examine all welds as a minimum.
   5. In addition to weld tests hereinbefore specified, doubler pads shall be air tested as stated in AWWA C206.
   6. Refer to Section 33 13 00 – Water Pipeline Testing and Disinfection for field nondestructive testing.

H. Onsite Observation: The pipe fabricator shall provide an experienced staff member to train the contractor’s installation crews regarding pipe handling, jointing, and backfilling. Training shall be provided for a minimum of two weeks at the beginning of the project, and as needed during construction. The staff member's duties shall include, but not be limited to, the following:
   1. Observe the installation and welding of the pipe and fittings.
   2. Report any concerns to the Engineer's onsite observer.
   3. Answer questions and provide assistance to the Engineer and the Contractor.

I. Certified Welding Inspector (CWI): Furnish the services of a certified welding inspector(s) for all shop and field welding as specified in AWWA C200 and C206. The certified welding inspector(s) shall 100 percent visually inspect all welds, verify proper procedures are being followed using qualified welders, supervise Contractor's non-destructive testing, and witness Engineer's non-destructive testing. The welding inspector(s) shall submit written certification that all welds were performed in conformance with these documents. All shop weld tests shall be reviewed and signed by the inspector(s).

J. Pipe Manufacturer/Fabricator: The manufacturer or fabricator of the pipe shall be experienced in fabricating pipe of similar diameters and wall thicknesses required for this Work and shall have the manufacturing capability to meet the schedule requirements of this project.

PART 2 - PRODUCTS

2.1 GENERAL

A. Unless otherwise indicated, steel pipe, linings and coatings shall conform to ANSI/AWWA C200, C205, C602, C209, C214, C215, C216, and C222, as applicable, subject to the following supplemental requirements. The pipe shall be of the diameter and wall thickness shown, shall be furnished complete with welded or gasket joints, as indicated in the Contract Documents, and all specials shall be provided as required in Section 33 11 12 - Steel Pipe Fabricated Specials. For pipe larger than 24 inches in diameter, the inside diameter after lining shall not be less than the nominal diameter indicated unless otherwise shown. Pipe 24 inches in diameter and smaller may be provided in standard outside diameters.

B. Markings: Legibly mark all pipes and specials in accordance with the laying schedule and marking diagram. Each pipe shall be numbered in sequence and said number shall appear on the laying schedule and marking diagram in its proper location for installation. All special pipe sections and fittings shall be marked at each end with top field centerline. The word "top" shall be painted or marked on the outside top spigot of each pipe section.

C. Handling and Storage: The pipe shall be handled by use of wide slings, padded cradles, or other devices, designed and constructed to prevent damage to the pipe coating/exterior. The use of chains, hooks, or other equipment which might injure the pipe coating/exterior will not be permitted. Stockpiled pipe shall be suitably supported and shall be secured to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials. Stockpiled pipe shall be supported on sand or earth berms free of rock exceeding 1 inch in diameter. The ends of all pipe shall be securely bulkheaded or otherwise sealed during transport to the jobsite. All pipe handling equipment and methods shall be acceptable to the Engineer.

D. Pay the cost of replacement or repair of pipe which is damaged at no increased cost to the Owner.

E. Strutting: Adequate strutting (stulling) shall be provided on all specials, fittings, and straight pipe so as to avoid damage or distortion to the pipe and fittings during handling, storage, hauling, and installation. The following requirements shall apply:
   1. The strutting shall be placed as soon as practicable after the pipe is fabricated or the plural component epoxy lining has been applied and shall remain in place while the pipe is loaded, transported, unloaded, installed and backfilled at the jobsite.
   2. The strutting materials, size and spacing shall be the responsibility of the Contractor and shall be adequate to prevent deflection and support the earth backfill plus any greater loads which may be imposed by the backfilling and compaction equipment. One strut shall be placed vertical oriented with the top of pipe. One set of struts shall be set 2 feet from each end of each pipe section and at a maximum interval of 15 feet in-between
   3. Any pipe damaged during handling, hauling, storage, or installation due to improper strutting shall be repaired or replaced.

F. Laying Lengths: Maximum pipe laying lengths shall not be limited unless specifically required by the Drawings. Contractor shall select lengths to accommodate the Contractor's operation.

G. Lining: The pipe lining shall have smooth dense interior surfaces and shall be free from fractures, excessive interior surface crazing and roughness.

H. Cathodic Protection System: Cathodic protection systems shall be applied to pipelines as shown on the Drawings. Refer to Section 13 47 13 - Cathodic Protection.

I. Closures and Correction Pieces: Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing indicated. The locations of correction pieces and closure assemblies shall be shown on the pipe layout diagrams and shall be subject to the Engineer's review. Any change in location or number of said items shall be approved by the Engineer.

J. Shop-Welded Surfaces: All weld seams on pipe surfaces that will have a flexible tape or polyolefin coating in accordance with Section 09 97 01 - Pipeline Coatings and Linings shall be ground such that the maximum weld bead height will not exceed 1/32 inch. All ground weld seams shall be smooth and free of all burrs. Do not grind into, or gouge, the adjacent pipe wall material.

2.2 MATERIALS

A. Cement: Cement for mortar shall conform to the requirements of ANSI/AWWA C205; provided, that cement for mortar coating shall be Type V, and mortar lining shall be Type II or V, per ASTM C 150. Fly ash or pozzolan shall not be used as a cement replacement.

B. Steel: Provide steel coils for spiral welded steel pipe or steel plate for straight seam welded steel pipe per AWWA C200 and as follows:
   1. Yield Strength: **42,000 psi** minimum. Measured yield strength shall not exceed 85% of measured tensile strength.
   2. Minimum Tensile Strength**: 60,000 psi**
   3. Coils: Steel coils shall be made from the continuous cast process or continuous cast slabs, fully killed, fine-grain practice conforming to the physical and chemical characteristics of ASTM A1018/A1018M, **SS Grade 45**. For sheet steel, the maximum allowable thickness variation shall be 0.010 inch under or over the nominal thickness.
   4. Plate: Steel plate shall be fully killed, conform to ASTM A20, and be manufactured to fine-grain practice conforming to the physical and chemical characteristics of ASTM A572/A572M, **Grade 50**. For plate steel, the maximum allowable thickness variation shall be 0.010 inch under or over the nominal thickness.

C. Pipe shall be manufactured as fabricated pipe per AWWA C200 as modified herein. ASTM pipe manufacturing standards referenced in AWWA C200 shall not be used. Pipe sections shall be fabricated by either of the following methods:
   1. Pipe sections may be spirally welded or fabricated from short cylindrical courses joined circumferentially by complete penetration butt joint welds with not more than

two longitudinal seams per course. Longitudinal seams shall be staggered on both sides of the pipe.

2. Pipe sections may be rolled or pressed from no more than three sheets the full length of the pipe and welded with no more than three longitudinal seams. Patching inserts, overlays, or pounding out of dents will not be permitted. Repair of notches or laminations on second ends will not be permitted. Damaged ends shall be removed as a cylinder and the section end properly prepared. Distorted or flattened lengths shall be rejected. A buckled section shall be replaced as a cylinder.

D. Charpy Tests

1. General. Steel used in production manufacturing of pipe and specials shall be tested for notch toughness using Charpy V-Notch tests per ASTM A 370. The test acceptance shall be 25 foot-pounds at a test temperature of 30 degrees F.
2. Charpy V-Notch tests shall be conducted on all steel used in fabricating pipe and reinforcement materials 0.5-inch or greater in thickness. Test outside diameter wrap of two coils minimum per heat lot.
3. The Owner may elect to increase the Charpy testing to include more steel than indicated above at a negotiated price.

2.3 SPECIALS AND FITTINGS

A. Unless otherwise required, all specials and fittings shall be in accordance with Section 33 11 12 - Steel Pipe Fabricated Specials and shall conform to the dimensions of ANSI/AWWA C208.

2.4 DESIGN OF PIPE

A. General: The pipe shall be steel pipe, plural component epoxy lined and coated as shown on the Drawings, with field welded joints or gasket as indicated. The pipe shall consist of a steel cylinder, with an exterior coating as indicated in Section 09 97 01 – Pipeline Coatings and Linings. Field lining will only be allowed where specifically indicated on the Drawings.

B. The pipe shall be manufactured, tested, inspected, and marked according to applicable requirements previously stated and except as hereinafter modified, shall conform to ANSI/AWWA C200.

C. Pipe Dimensions: The pipe shall be of the diameter and wall thickness shown on the Drawings. The minimum steel cylinder thickness for each pipe size shall be as indicated.

D. Specials Dimensions: The specials shall be of the diameter and wall thickness indicated on the Drawings, or as specified in Section 33 11 12 - Steel Pipe Fabricated Specials.

E. Joint Design: Unless otherwise shown on the Drawings, the standard field joint for steel pipe shall be single-welded (fully circumferential) lap joint. Mechanically coupled, or flanged joints shall be required where indicated on the Drawings. Butt-strap joints shall be used only where required for closures or where indicated. The joints furnished shall have the same or higher pressure rating as the abutting pipe. Provide air test tapped holes for each double welded lap joint as defined in Section 33 13 00 - Water Pipeline Testing and Disinfection.

F. Lap joints prepared for field welding shall be in accordance with ANSI/AWWA C200. The method used to form, shape and size bell ends shall be such that the physical properties of

the steel are not substantially altered. Unless otherwise approved by the Engineer, bell ends shall be formed by an expanding press or by the pipe being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. The ends shall not be rolled. Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.

G. Moderate deflections and long radius curves may be made by means of beveled joint rings, by pulling standard joints, by using short lengths of pipe, or a combination of these methods; provided that pulled joints shall not be used in combination with bevels and maximum joint deflections are not exceeded. The maximum total allowable angle for beveled joints shall be 5 degrees per pipe joint. Bevels shall be provided on the bell ends. Mitering of the spigot ends will not be permitted. The maximum allowable angle for pulled joints shall be 75 percent of the manufacturer's recommendations or the angle which results from a ¾-inch pull out from normal joint closure, whichever is less. In no case shall pulled joints result in a gap between the bell and spigot at the weld location that exceeds 1/8 inch. All horizontal deflections or fabricated angles shall fall on the alignment, as shown.

H. All vertical deflections shall fall on the alignment within laying tolerance as described in Section 3.1.

I. Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as indicated or as otherwise acceptable to the Engineer. Holdback areas shall be coated as hereinafter specified.

J. Temperature Control Lap Joint: A special longer bell end (temperature control lap joint) shall be provided at a maximum spacing of 400 feet to account for movement of the installed pipe due to temperature changes. The pipe manufacturer shall determine the length required for the longer bell as defined by the Contractor's pipe laying procedures and the location of the special bell. Minimum temperature control lap joint length shall be as shown on the Drawings.

K. Joint Shop Coating: All holdback areas for welded joints, all butt straps, and all bell and spigot joint rings for rubber-gasketed joints shall be thoroughly cleaned and given a shop coat of rust-inhibitive primer. The surface preparation and primer shall be compatible with the intended finish coating as specified in Section 09 90 00 – Painting and Coating, Section 09 97 01 – Pipeline Coatings and Linings, as applicable.

L. Shop Fit Test
1. Not required.

M. The pipe ends shall be match marked after shop assembly.

2.5 PLURAL COMPNENT EPOXY LINING

A. Plural Component Epxoy Lining for Shop Application: Where indicated on the Drawings, interior surfaces of all steel pipe, fittings, and specials shall be cleaned and lined in the shop with plural component epoxy lining applied centrifugally. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or strutting. The lining machines shall be of a type that has been used successfully for similar work and

shall be approved by the Engineer. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found faulty at the delivery site, or after installation, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications at no additional cost to the Owner.

B. The minimum lining thickness shall be in accordance with Section 09 97 01 Pipeline Coatings and Lining.

C. The pipe shall be left bare where field joints occur as indicated. Ends of the linings shall be left square and uniform. Feathered or uneven edges will not be permitted.

D. Defective linings, as determined by the Engineer, shall be removed from the pipe wall and shall be replaced to the full thickness required. Defective linings shall be cut back to a square shoulder in order to avoid feather edged joints.

2.6 EXTERIOR COATING OF PIPE

A. Exterior Coating of Steel Pipe: The exterior coating of all steel pipe shall be in accordance with Section 09 97 01 – Pipeline Coatings and Linings.

2.7 PIPE APPURTENANCES

A. Pipe appurtenances shall be in accordance with the requirements of Section 40 05 00 - Piping, General.

2.8 PIPELINE MARKING TAPE

A. Metallic tape: Terra Tape Sentry Line Detectable manufactured by Reef Industries, Inc., 9209 Alemeda Genoa Road, Houston, TX 77075, www.reefindustries.com; or approved equal, having the following essential characteristics:
   a. Aluminum foil encased in high visibility inert polyethylene jacket.
   b. Total thickness: 6.0 mils, minimum.
   c. Core foil thickness: 0.30 mils, minimum.
   d. Width: 6 inches, minimum.
   e. Imprinted on one side, 1-inch-tall, permanent black lettering.
   f. Color: as listed below.
   g. Joining clips shall be manufacturer's standard tin or nickel coated.

B. Plastic tape: Terra Tape Extra Stretch manufactured by Reef Industries, Inc., 9209 Alemeda Genoa Road, Houston, TX 77075, www.reefindustries.com; or equal, having the following essential characteristics:
   a. Polyolefin or similar chemically inert material unsusceptible to alkalies, acids, and chemicals and solvents likely in the soil.
   b. Thickness: 8.0 mil, minimum.
   c. Width: 12 inches minimum.
   d. Color: as listed in below.
   e. Imprinted on one side, 1-inch-tall, permanent black lettering on a colored background.

2.9 MARKERS

A. Provide pipeline markers at the locations indicated. Markers in open areas shall be High Visibility Tri-View Utility Marking Posts as manufactured by Rhino Marking and Protection Systems (www.rhinomarkers.com). Coordinate color and lettering with Owner prior to installation. Markers shall be provided at the following locations:
   1. Both sides of street and canal crossings.
   2. At locations of cathodic protection test stations (see test station table).
   3. At the beginning and end of open areas and at a maximum interval of 500-ft.

B. Brass Caps: Caps shall be 2-1/2-inch diameter brass caps with posts set by epoxy into holes drilled into the curb adjacent to the pipeline. Brass caps and monuments shall be provided in locations as described in the plans. Caps shall be stamped as shown on the details and shall be provided at the following locations:
   1. Fittings or elbows.
   2. Both sides of street and canal crossings.
   3. Within deck of concrete structures (manholes, vaults, etc.)

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE

A. Handling and Storage: All pipe, fittings, and specials shall be carefully handled and protected against damage to lining and coating/interior and exterior surfaces, impact shocks, and free fall. All pipe handling equipment shall be acceptable to the Engineer. Pipe shall not be placed directly on rough ground but shall be supported in a manner which will protect the pipe against injury whenever stored at the trench site or elsewhere. Pipe shall be handled and stored at the trench site in accordance with the requirements stated below. No pipe shall be installed when the lining or coating/interior or exterior surfaces show cracks or other damage that may be harmful as determined by the Engineer. Such damaged lining and coating/interior and exterior surfaces, shall be repaired to the satisfaction of the Engineer, or a new undamaged pipe shall be furnished.

B. All pipe damaged prior to Substantial Completion shall be repaired or replaced by the Contractor at no additional cost to the Owner.

C. Inspect each pipe and fitting to ensure that there are no damaged portions of the pipe. Remove or smooth out any burrs, gouges, weld splatter or other small defects prior to laying the pipe.

D. Before placement of pipe in the trench, each pipe or fitting shall be thoroughly cleaned of any foreign substance, which may have collected thereon and shall be kept clean at all times thereafter. For this purpose, the openings of all pipes and fittings in the trench shall be closed during any interruption to the Work.

E. Lifting points shall be no closer than the 1/3 and 2/3 points along the length of the Section. Contractor shall be responsible for selecting lifting points that when used, do not result in damage to the pipe.

F. Excavations shall be made as needed to facilitate removal of handling devices after the pipe is laid. Excavation shall be made as needed outside the normal trench section at field joints to permit adequate access to the joints for field connection operations and for application of coating on field joints.

G. Where necessary to raise or lower the pipe due to unforeseen obstructions or other causes, the Engineer may change the alignment and/or the grades. Such change shall be made by the deflection of joints, short lengths of pipe, by the use of beveled joint rings, or by the use of additional fittings. However, in no case shall the deflection in the joint exceed 75 percent of the maximum deflection recommended by the pipe manufacturer or the amount that results in more than a 1/8-inch gap at the weld location, whichever is less. No joint shall be misfit any amount which will be detrimental to the strength and water tightness of the finished joint.

H. Except for short runs which may be permitted by the Engineer, pipes shall be laid uphill on grades exceeding 10 percent. Pipe which is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement. All bends shall be properly installed as shown.

I. Pipe struts shall be left in place until backfilling operations have been completed for pipe 42 inches in diameter and larger. Struts in pipe smaller than 42 inches may be removed immediately after laying, provided, that the deflection of the pipe during and after backfilling does not exceed that specified. After the backfill has been placed to a minimum of 3-feet, the struts shall be removed by the Contractor and shall remain the property of the Contractor. Struts shall not be removed with a torch or any other method that may damage the pipe lining or coating. The parent pipe material shall not be nicked, gouged, or damaged during strut removal. All repairs of gouges or nicks in the parent material shall be made using 3/32-inch maximum diameter E-6010 welding electrodes with a maximum heat input of 5.6 kj per inch. Tack welds, stull metal, weld splatter, slag, and burrs that remain attached to the parent metal surface after cutting shall be ground to within 1/32 inch of the parent metal. Grinding shall not penetrate the parent metal. The Contractor shall notify the Engineer prior to grinding. Following grinding, all pipe surfaces at the tack weld shall be visually inspected for defects. All defects deeper than 1/16 inch shall be repaired by welding in accordance with ANSI/AWSD.1.1 and AWWA/ANSI C206. All inspection work shall be performed by a certified welding inspector.

J. For pipe backfilled with CLSM, the pipe shall be laid directly on moist sandbags or other suitable supports approved by the Engineer in preparation for CLSM pipe zone material. Sandbags shall be placed to provide at least 6 inches of CLSM below the bottom of the pipe. Sandbags shall be spaced at a maximum interval of 8 feet and one set shall be placed within 3 feet on both sides of each joint. The Contractor shall provide additional sandbags as needed to support the pipe on line and grade. For pipe bedded in granular material, no blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe. Excavations shall be made as needed to facilitate removal of handling devices after the pipe is laid. Bell holes shall be formed at the ends of the pipe to prevent point loading at the bells or couplings. Excavation shall be made as needed outside the normal trench section at field joints to permit adequate access to the joints for field connection operations and for application of coating on field joints.

K. At all times, means shall be provided to prevent the pipe from floating. Take all necessary precautions to prevent the pipe from floating due to water entering the trench or from backfilling with CLSM. The Contractor shall assume full responsibility for any damage due to this cause and shall at its own expense restore and replace the pipe to its specified condition and grade if it is displaced due to floating. Maintain the inside of the pipe free from foreign materials and in a clean and sanitary condition until its acceptance by the Owner.

L. Bulkheads
   1. Prior to shipment of pipe with cement mortar lining the lining shall be wetted then a suitable bulkhead shall be attached to each end of the pipe section. This bulkhead shall remain in place and in good condition through transit to the Project.
   2. During construction the openings of all pipe and specials where the pipe and specials have been cement-mortar lined in the shop shall be protected with suitable bulkheads to maintain a moist atmosphere and to prevent unauthorized access by persons, animals, water or any undesirable substance. The bulkheads shall be so designed to prevent drying out of the interior of the pipe. Introduce water into the pipe as needed to keep the mortar moist where moisture has been lost due to damaged bulkheads.

M. Pipe Cleanup: As pipe laying progresses, keep the pipe interior free of all debris. Completely clean the interior of the pipe of all sand, dirt, mortar splatter and any other debris following completion of pipe laying and any necessary interior repairs prior to testing and disinfecting the completed pipeline.

N. Installation Tolerances: Each section of pipe shall be laid in the order and position shown on the laying diagram and the following requirements:
   1. Each section of pipe having a nominal diameter less than 48 inches shall be laid to line and grade, within plus or minus 2 inches horizontal deviation and plus or minus 1 inch vertical deviation.
   2. Each section of pipe having nominal diameter 48 inches and larger shall be laid to line and grade, within plus or minus 5 percent of diameter horizontal deviation and plus or minus 2.5 percent of diameter vertical deviation.
   3. In addition to the horizontal and vertical tolerances above, lay the pipe so that no high or low points other than those on the laying diagram are introduced.
   4. Pipe deflection, after backfill but prior to installation of lining, if applied, shall not exceed 1.5 percent for plural component epoxy lined pipe. Deflection shall be measured by the difference in vertical inside diameter in the installed pipe and the manufactured pipe.
   5. Pipe not conforming to these criteria or which otherwise impact the ability to complete the Work shall be removed and reinstalled in full conformance with the Contract Documents at no additional cost to the Owner.
   6. For each section of pipe, record the invert elevation at the lower end and incorporate the data on the Record Drawings.

O. Protection of Pipe: At locations where the Contractor proposes to cross the installed pipeline with heavy equipment, precautions as approved by the Engineer shall be taken to protect the pipe from damage. Acceptable precautions include: backfilling the pipe trench as necessary to protect the pipe, concrete encasing the pipe, and placing steel plating over the pipe. Any damage to the pipe caused by the Contractor's operation or his equipment shall be repaired at no additional cost to the Owner.

3.2 WELDED JOINTS

A. Welding Procedures, Welding Qualifications, and Testing

1. Field welding procedures, welders, welding operators, and tackers shall be qualified in accordance with AWS D1.1 and as defined in Section 3 of ANSI/AWWA C206 or ANSI/AWWA C200, as applicable. All qualifications shall be in accordance with all-position pipe tests as defined in Section 5 of AWS D1.1.
2. For field welding, the welder qualification testing shall be performed at the site. Previous qualifications will not be accepted. The Contractor shall obtain the services of an independent testing laboratory to perform the welder qualification onsite. Copies of all test data and certifications shall be provided to the Engineer. All costs for welder qualification testing shall be at no increased cost to the Owner.
3. Upon completion of each field-welded joint, the welding operator shall mark his regularly assigned identification number and the last two numbers of the year in which the Work was completed, or the Contractor may have a records system that traces a welder's work completion to a specific joint. Steel stamping directly on piping will not be permitted unless "low stress" die stamps, such as interrupted dot or round nose types, are used.
4. All single welded lap joints will be inspected by the CONTRACTOR in the presence of the Engineer using magnetic particle or dye penetration methods. Field butt welds will be inspected by the CONTRACTOR in accordance with the requirements of API 1104 by the radiographic method and the acceptance criteria of API 1104. Magnetic particle testing is not required for seal welds.
5. All double welded lap joints and butt strap joints shall be air tested by the CONTRACTOR in the presence of the Engineer in accordance with Section 33 13 00 - Water Pipeline Testing and Disinfection. Repairs and retesting shall be required if any loss of pressure occurs. All double welded lap joints will also be inspected by the CONTRACTOR in the presence of the Engineer using magnetic particle or dye penetration methods.
6. The Contractor shall inform the Engineer before completed weld joints are to be backfilled so that the joint may be inspected. The Contractor shall assume all costs of exposing backfilled joints for inspection when backfilling preceded the inspection.
7. Personnel performing visual inspection of welds shall be qualified and currently certified as Certified Welding Inspectors (CWI) in accordance with AWS QC1, Standard for Qualification and Certification of Welding Inspectors. Personnel performing nondestructive tests shall be qualified and certified to the requirements of SNT-TC-1A.
    a. The Engineer may also order nondestructive testing by an independent testing laboratory in addition to any testing specified herein. Except as otherwise specified herein, all costs for the independent testing laboratory to inspect and test field welds will be paid for by the Owner. If the weld is defective, the inspection costs shall be paid for by the Contractor. Defective welds shall be repaired and retested at the Contractor's expense.
    b. Test reports of all laboratory tests shall be submitted as provided in the quality control section.

B. Where exterior welds are performed, adequate space shall be provided for welding and inspection of the joints.

C. Lap Welded Joints: During installation of welded steel pipe in either straight alignment or on curves, the pipe shall be laid so that at any point around the circumference of the joint there is a minimum lap as shown on the Drawings.

D. Butt Straps: Where used or required, shall be as shown on the Drawings.

E. After the pipe and pipe joint are properly positioned in the trench, weld and provide external joint protection for all joints except the special temperature control lap joint hereinafter specified. The length of pipe between special temperature control joints shall be backfilled to at least one foot above the top of the pipe as hereinafter specified. The special temperature control joints shall be welded after the pipe is backfilled to at least one foot above the top of the pipe for the full distance between the temperature control joints upstream and downstream. Joint protection shall be provided for special temperature control joints after completion of the joint welds and tests as specified. Care shall be exercised during the initial backfilling to prevent movement of the pipe and to prevent any backfill material from being deposited on the special temperature control joint.

F. Control of Temperature Stresses

1. Control temperature stresses in accordance with AWWA C206, the approved temperature stress control submittal, and these Specifications. Provide special temperature control lap joints at intervals of 400 feet or less, unless otherwise approved by the Engineer.
2. To control temperature stresses, the unbackfilled special temperature control joint areas of all pipe shall be shaded from the direct rays of the sun by the use of properly supported awnings, umbrellas, tarpaulins, or other suitable materials until the pipe is backfilled at least 1 foot over the top of the pipe. The "temperature control joint area" is defined as the entire length of pipe left exposed near a control joint after placing the pipe backfill between it and the other control joints in each direction. The term "special temperature control joint area" is defined as the entire length of pipe left exposed near a control joint after placing the backfill between it and the other control joints in each direction. Shading materials at the joint area shall not rest directly on the pipe but shall be supported to allow air circulation around the pipe. Shading of the pipe joints need not be performed when the ambient air temperature is below 45 degrees F.
3. At intervals not exceeding 400 feet along welded reaches of the pipeline, at the first regular lap-welded field joints outside concrete encasements and structures, and where shown, the pipe shall be supplied with a special temperature control lap joint and laid with an initial lap of not less than 3 inches greater than the typical lap joint. Where temperature control lap joints occur in a traveled roadway or other inconvenient location, the location of the joint may be adjusted, as acceptable to the Engineer.
4. Provide and install thermocouple temperature gauges to monitor the temperature of the steel pipe wall on the inside top of the pipe as it lays in the trench. All pipe temperature requirements specified herein shall be measured at the top inside of the steel cylinder. Specific temperature requirements for the pipeline steel cylinder shall be met prior to installation of the controlled low strength material (CLSM), during and after placement of CLSM, and during welding of the special temperature control joints. If atmospheric conditions do not allow the conditions to be met, supplemental

cooling shall be required by the Contractor. The following outlines the specific temperature control requirements.

a. Prior to and during placement of the CLSM, the pipeline steel temperature shall be at or below 90 degrees F. The specified temperature shall be maintained for at least three hours after the placement of CLSM. The specified temperature shall be maintained until the line is fully backfilled. Provide supplemental cooling as required.

b. Placement of CLSM shall proceed in the direction of pipe laying from one special temperature control joint to the next. During placement of CLSM, the lead end of the pipe section (toward the next special temperature control joint) shall be left unbackfilled or otherwise unrestrained such that the end of the pipe is free to move in response to expansion or contraction due to temperature changes. CLSM shall not be placed in a direction which would result in CLSM placement proceeding in a direction toward previously or simultaneously placed CLSM without the written permission of the Engineer. The direction of CLSM placement will not be limited for placement at the short unbackfilled section immediately adjacent to the special temperature control joints.

c. During periods between CLSM placement operations, any section of pipeline that is backfilled with CLSM shall be shaded from the direct rays of the sun by the use of properly supported awnings, umbrellas, tarpaulins, or other suitable materials until the pipe is backfilled at least 1 foot over the top of the pipe. The temperature of the partially backfilled pipe shall not be allowed to exceed 110 degrees Fahrenheit at any time. Provide supplemental cooling as required. Shading materials shall not rest directly on the pipe but shall be supported to allow air circulation around the pipe. Shading of the partially backfilled pipe need not be performed when the Contractor can demonstrate to the satisfaction of the Engineer, using thermocouple data, that shading is not necessary to the Contractor to meet the specified temperature requirement.

d. Prior to welding the special temperature control joints, the pipeline extending 400 feet each direction from the joint shall be maintained at or below 85 degrees F. Additionally, the pipeline extending 400 feet each direction from the joint shall be backfilled with CLSM to at least one foot over the top of the pipe. At the specified temperature, the special temperature control joints can be welded. Begin and complete the weld during the coolest interval of suitable length within a 24-hour day. Use the thermocouple temperature data to demonstrate to the Engineer the coolest interval of the day.

e. After welding any temperature control joint, the pipe temperature for 150 feet in each direction from the control joint shall be maintained below 110 degrees F for a minimum of 24 hours after the temperature control joint area has been backfilled to at least 1 foot over the top of the pipe. This requirement is in addition to the shading and CLSM placement temperature requirements indicated herein.

G. Prior to the beginning of pouring CLSM or beginning the welding procedure, any tack welds or joint stops used to position the pipe during laying shall be removed. Any annular space between the faying surfaces of the bell and spigot shall be equally distributed around the circumference of the joint by shimming, jacking, or other suitable means. The weld shall then

be made in accordance with ANSI/AWWA C206. Where more than one pass is required, all dirt, slag, and flux shall be removed before the succeeding bead is applied.

H. Testing of Joints: The pipeline joints shall be tested as specified herein and in Section 33 13 00 - Water Pipeline Testing and Disinfection.

I. Following tests of the joint, the exterior joint spaces shall be coated in accordance with these Specifications after which backfilling may be completed.

J. Joints: The pipe ends shall be cut straight on joints where butt straps are used for realignment, adjustment, or deflection, and fillet welds shall be made as indicated.

K. Repair of Welds: All welds that are defective shall be repaired by the Contractor to meet the requirements of this Section at no additional cost to the Owner. Defects in welds or defective welds shall be removed, and that section of the joint shall then be rewelded. Only sufficient removal of defective material that is necessary to correct the defect is required. After the repair is made, the joint shall be checked by repeating the original test procedure. Welds deficient in size shall be repaired by adding weld metal.

3.3 JOINT COATING AND LINING

A. General: The interior and exterior joint recesses shall be thoroughly wiped clean and all water, loose scale, dirt and other foreign material shall be removed from the inside surface of the pipe. The grout for joint coating and lining shall be cement grout in accordance with Section 03 60 00 - Grouting, except that composition shall be one part cement to two parts sand and sufficient water for dry-pack consistency

B. Joint Coating: In accordance with the requirements of Section 09 97 01 – Pipeline Coatings and Linings.

C. Joint Lining: In accordance with the requirements of Section 09 97 01 – Pipeline Coatings and Linings.

3.4 INSTALLATION OF PIPE APPURTENANCES

A. Installation of Valves: All valves shall be handled in a manner to prevent any injury or damage to any part of the valve. All joints shall be thoroughly cleaned and prepared prior to installation. Adjust all stem packing and operate each valve prior to installation to insure proper operation. Valves (body and seat) shall not be subjected to test pressures greater than manufacturer's recommendation. In some cases this may require an increase in the valve pressure class.

B. All buried valves shall be coated and protected in accordance with Section 09 97 01 - Pipeline Coatings and Linings.

C. All valves shall be installed so that the valve stems are plumb and in the location indicated.

D. Installation of Flanged Joints: Before the joint is assembled, the flange faces shall be thoroughly cleaned of all foreign material with a power wire brush. The gasket shall be centered and the connecting flanges drawn up watertight without unnecessarily stressing the

flanges. All bolts shall be tightened in a progressive diametrically opposite sequence and torqued with a suitable, approved and calibrated torque wrench. All clamping torque shall be applied to the nuts only.

E. All buried flanges shall be coated and protected in accordance with Section 09 97 01 - Pipeline Coatings and Linings.

F. Flexible Coupled Joints: When installing flexible couplings, care shall be taken that the connecting pipe ends, couplings and gaskets are clean and free of all dirt and foreign matter with special attention being given to the contact surfaces of the pipe, gaskets and couplings. The couplings shall be assembled and installed in conformity with the recommendation and instruction of the coupling manufacturer.

G. Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer. Coupling bolts shall be tightened so as to secure a uniform annular space between the follower rings and the body of the pipe with all bolts tightened approximately the same amount. Diametrically opposite bolts shall be tightened progressively and evenly. Final tightening shall be done with a suitable, approved and calibrated torque wrench set for the torque recommended by the coupling manufacturer. All clamping torque shall be applied to the nut only.

H. Upon completion of the coupled joint, the coupling and bare metal of the pipe shall be cleaned, primed and protected in accordance with the requirements of Section 09 97 01 - Pipeline Coatings and Linings.

3.5 CORROSION CONTROL

A. Cathodic Protection: Corrosion mitigation and testing materials shall be provided where indicated and in accordance with Section 13 47 13 - Cathodic Protection.

3.6 MARKING TAPE INSTALLATION

A. As shown on the Drawings.

3.7 PIPELINE TESTING

A. The steel pipe shall be hydrostatically tested as specified in Section 33 13 00 – Water Pipeline Testing and Disinfection.

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SECTION 33 11 12
STEEL PIPE FABRICATED SPECIALS (AWWA C200, MODIFIED)

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide all bends, reducers, wyes, tees, crosses, outlets, manifolds and other steel plate specials, complete in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ASME B 16.9	Factory-Made Wrought Steel Butt Welding Fittings
ASTM E 165	Practice for Liquid Penetrant Examination
ANSI/AWWA C200	Steel Water Pipe 6 In and Larger
ANSI/AWWA C205	Cement Mortar Lining and Coating – Shop Applied
ANSI/AWWA C206	Field Welding of Steel Water Pipe
ANSI/AWWA C207	Steel Pipe Flanges for Waterworks
ANSI/AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
ANSI/AWWA C602	Cement-Mortar Lining of Water Pipelines - 4 In (100 mm) and Larger - In Place
ASTM A234	Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ANSI/AWS D.1.1	Structural Welding Code - Steel
API Standard 1104	Welding Pipelines and Related Structures
AWWA M-11	Steel Water Pipe - A Guide for Design and Installation
ASME	Boiler and Pressure Vessel Code

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings: Submit shop drawings including line and layout diagrams of all steel pipe fabricated specials in accordance with the requirements in Section 01 33 20 – Submittal Procedures. All submittals required for steel pipe and related work as listed in Section 33 11 11 - Steel Pipe, shall also be required for specials. Shop drawings shall indicate the type, size, and location of all reinforcement pieces.

B. Design calculations shall be submitted to the Engineer for review prior to manufacture of steel pipe fabricated specials.

C. Certifications: A certified affidavit of compliance with referenced Specifications and these Contract Documents shall be furnished for all steel pipe fabricated specials and other products or materials provided under this Section.

1.4 QUALITY ASSURANCE

A. Inspection: All specials shall be subject to inspection at the place of manufacturer/ fabrication as outlined in Section 33 11 11 - Steel Pipe.

B. Shop Testing of Steel Pipe Fabricated Specials:
   1. If steel pipe fabricated specials have been fabricated from untested straight pipe, they shall be hydrostatically tested with a pressure equal to 1-1/2 times the design working pressure shown on the Drawings. If steel pipe fabricated specials have been fabricated from successfully tested straight pipe, no hydrostatic test shall be required unless otherwise indicated. In no case shall shop test pressure be less than 150 psi. All tees with crotch plates shall be hydrostatically tested as indicated regardless of whether or not the straight pipe sections used were previously tested.
   2. All welds shall be non-destructive tested at the specials fabricator's facility as specified below for various weld categories. Testing shall include submitting written documentation of procedures per Section V, and acceptance criteria shall be in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.
      a. Butt Joint Welds: Spot radiographically examine pipe in accordance with paragraph UW-52 of the ASME Boiler and Pressure Vessel Code Section VIII, Division 1. If, in the opinion of the Engineer, the welds cannot readily be radiographed, they shall be 100 percent ultrasonically examined.
      b. Fillet Welds: 100 percent examine all fillet welds using the magnetic particle inspection method.
      c. Groove Welds: 100 percent ultrasonically examine all groove welds that cannot be readily radiographically spot examined.
      d. Welds on pipe seams for previously successfully tested straight pipe do not need to be retested.
      e. All Welds: Contractor's certified welding inspector shall 100 percent visually examine all welds as a minimum.
      f. In addition to weld tests herein before specified, doubler pads shall be air tested as stated in AWWA C206.
      g. Refer to Section 33 13 00 - Water Pipeline Testing and Disinfection for field non-destructive testing.
   3. Where welded test heads or bulkheads are used, extra length shall be provided to each opening of the special. After removal of each test head, the special shall be trimmed back to the design points with all finished plate edges ground smooth, straight, recoated and prepared for the field joint.
   4. Testing shall be performed before pipe and joints have been coated or lined.
   5. Perform tests at no additional cost to the Owner. The Engineer shall have the right to witness all testing conducted by the Contractor, provided that the Contractor's schedule is not delayed for the convenience of the Engineer.

6. In addition to those tests specifically required, the Engineer may request additional samples of any material including mixed concrete and lining and coating samples for testing by the Owner. The additional samples shall be furnished at no additional cost to the Owner.

C. Field Testing: Field testing shall conform to the requirements of Section 33 13 00 - Water Pipeline Testing and Disinfection.

D. Welding Procedure Specifications: All welding procedures used to fabricate pipe shall be in accordance with Section 33 11 11 - Steel Pipe.

E. Welder Performance Qualifications: All welder performance qualifications shall be in accordance with Section 33 11 11 - Steel Pipe.

F. Certified Welding Inspector: A certified welding inspector shall be provided for shop fabricated work and shall have the responsibilities outlined in Section 33 11 11 - Steel Pipe.

G. Fittings and Specials Fabricator:
1. Experienced in fabrication of fittings and specials of similar diameters and wall thickness required for the Work.
2. Demonstrate current production capability for volume of Work required for the Project.
3. Experience shall be for project requiring fabrication to AWWA C200/208 standards of at least 25 fittings, with wall thickness 0.375-inch or larger within the 5-year period preceding the bid date.
4. Experience requirement shall apply to the fabrication plant facility and responsible personnel, not the firm which owns the facility or employs the personnel.
5. See Section 33 11 11 – Steel Pipe for qualifications for steel pipe fabricators.

H. Fabrication: All specials shall be fabricated in the shop. No field fabrication of specials will be allowed.

PART 2 - PRODUCTS

2.1 GENERAL

A. Steel pipe fabricated specials (specials) are defined as fittings, closure pieces, bends, elbows, reducers, wyes, tees, crosses, outlets, manifolds, steel pipe wall sleeves, and other steel plate specials wherever located, and all piping above ground or in structures.

2.2 DESIGN

A. Design: Except as otherwise provided herein, specials shall be fabricated from materials or straight pipe in full conformance with the requirements of Section 33 11 11 - Steel Pipe, ANSI/AWWA C200, and the dimensions of ANSI/AWWA C208. All fittings and specials shall be properly reinforced to withstand the internal pressure, with circumferential and longitudinal, or external loading conditions, whichever is greater. The minimum thickness of plate for pipe from which specials are to be fabricated shall be no less than the thickness of the adjacent mainline pipe, the thickness shown, or the following, whichever is thicker:

Nominal Pipe Diameter (in)	Pipe Manifolds, Piping Above Ground, and Piping in Structures	Elbows, Bends, and Reducers
30 and under	Standard Weight	Standard Weight
Over 30	3/8-inch	Same as Adjacent Pipe

B. Pipe installed on saddle supports shall be designed to limit the longitudinal bending stress to a maximum of 10,000 psi. Design shall be in accordance with the provisions of Chapter 7 of AWWA M-11, and other applicable industry standards.

C. Joints: All joints and related work for field assembly of the pipe and specials shall conform to Section 33 11 11 - Steel Pipe. All shop joints shall be complete penetration butt-welds unless otherwise shown.

2.3 FABRICATION AND MATERIALS

A. General: Reinforcement for wyes, tees, outlets, and nozzles shall be as shown. Shop welding shall conform to the applicable provisions of the ASME Boiler and Pressure Vessel Code. Field welding shall conform to ANSI/AWS D1.1 and ANSI/AWWA C206. Specials and fittings shall be equal in pressure design strength and shall have the same lining and coating as the adjoining pipe. Unless otherwise indicated, the minimum radius of elbows shall be 2.5 times the pipe diameter and the maximum miter angle on each section of the elbow shall not exceed 11-1/4 degrees resulting in a maximum deflection angle of 22.5 degrees per miter weld as recommended in AWWA C208.

B. Specials and fittings that cannot be mechanically lined and coated shall be lined and coated by hand-application, using the same materials as are used for the pipe and in accordance with the applicable AWWA or ASTM Standards, and as modified in Section 09 97 01 - Pipeline Coatings and Linings, or by other applicable sections in these Specifications. Coating and lining applied in this manner shall provide thickness and protection equal to that specified for the pipe. Fittings may be fabricated from pipe that has been mechanically lined and/or coated. Areas of lining and coating that have been damaged by such fabrication shall be removed and reapplied by hand-applications.

C. Access manholes with covers shall be as indicated. All threaded outlets shall be forged steel suitable for 3,000-psi service, and shall be as manufactured by Vogt or equal.

D. Moderate deflections and long radius curves may be made by means of beveled joint rings, by pulling standard joints, by using short lengths or pipe, or a combination of these methods; provided that pulled joints shall not be used in combination with bevels and maximum joint deflections are not exceeded. The maximum total allowable angle for beveled joints shall be 5 degrees per pipe joint. Bevels shall be provided on the bell ends. Mitering of the spigot ends will not be permitted. The maximum allowable angle for pulled joints shall be 75 percent of the manufacturer's recommendations or the angle which results from a 3/4-inch pull out from normal joint closure, whichever is less. In no case shall pulled joints result in a gap between the bell and spigot at the weld location that exceeds 1/8 inch. All horizontal deflections or fabricated angles shall fall on the alignment, as shown.

E. All vertical deflections shall fall on the alignment and at locations adjacent to underground obstructions, points of minimum earth cover, and pipeline outlets and structures, the pipe angle points shall match the angle points indicated.

F. Outlets, Tees, Wyes, and Crosses
   1. Outlets 14-inch and smaller shall be fabricated from ASTM A 53, Type E or S, Grade B, standard weight steel pipe in the standard outside diameters, i.e., 14, 12-3/4-inch, 10-3/4-inch, 8-5/8-inch, 6-5/8-inch, and 4-1/2-inch. Wall thickness and collar reinforcing shall be as shown.
   2. In lieu of collar reinforcement as shown, pipe or specials with outlets may be fabricated in their entirety of steel plate having a thickness equal to the sum of the pipe wall plus the required reinforcement.
   3. Where required by Manual M-11 or other industry standard, the design procedure for crotch plate reinforcement, such reinforcement shall be required.

G. Steel Welding Fittings: Steel welding fittings for pipe spools and fittings smaller than 24 inches in diameter shall be in accordance with ANSI B16.9 conforming to ASTM A 234. Use standard weight. Taper pipe wall at welds at 4:1 for connection to pipe of different wall thicknesses. The Contractor shall be fully responsible for coordinating the difference in diameter convention between these specials and AWWA C200/C208 pipe and fittings to provide complete piping systems as shown.

H. Ends for Mechanical-Type Couplings: Except as otherwise indicated, where mechanical-type couplings are indicated, the ends of pipe shall be banded with Type C collared ends using double fillet welds. Where pipe 12-inch and smaller is furnished in standard schedule thicknesses, and where the wall thickness equals or exceeds the coupling manufacturer's minimum wall thickness, the pipe ends may be grooved.

I. Lining: All requirements pertaining to thickness, application and curing of cement mortar lining indicated for straight pipe shall apply to specials, with the following provision. If the special cannot be lined centrifugally or with field lining equipment, it shall be lined by hand. In such case, the lining shall be reinforced with welded wire fabric positioned approximately in the center of the lining and in accordance with AWWA C205 for lining of specials.

J. Coating: All requirements pertaining to thickness, application and curing of coating indicated for straight pipe shall apply to specials. Unless otherwise indicated the coating on the buried portion of a pipe section passing through a structure wall shall extend to the center of the wall, or to the wall flanges, if one is indicated. Pipe above ground or in structures shall be shop primered and field-painted in accordance with Section 09 90 00 – Painting and Coating.

K. Marking: A mark indicating the true vertical axis of the special shall be placed on the top and bottom of the special.

L. Shop Welded Surfaces: All weld seams on pipe surfaces that will have a flexible tape or polyolefin coating in accordance with AWWA C209, C214, C215, or C216 shall be ground such that the maximum weld bead height will not exceed 1/32 inch. All ground weld seams shall be smooth and free of all burrs.

M. Portions of wall sleeves that penetrate into hydraulic structures and will be embedded into concrete shall be shop lined and coated in accordance with requirements for submerged conditions as outlined in Section 09 90 00 – Painting and Coating.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide all fittings, closure pieces, elbows, bends, reducers, wyes, tees, crosses, outlets, manifolds, and other steel plate specials, bolts, nuts, gaskets, jointing materials, and all other appurtenances as indicated to provide a complete and workable installation. Where pipe support details are indicated, the supports shall conform thereto and shall be placed as indicated; provided, that the support for all exposed piping shall be complete and adequate regardless of whether or not supporting devices are specifically indicated. Where indicated, concrete thrusts blocks and welded joints shall be provided. At all times when the Work of installing pipe is not in progress, all openings into the pipe and the ends of the pipe in trenches or structures shall be kept tightly closed to prevent entrance of animals and foreign materials.

B. Take all necessary precautions to prevent the pipe from floating due to water entering the trench or from backfilling with CLSM. The Contractor shall assume full responsibility for any damage due to this cause and shall at its own expense restore and replace the pipe to its specified condition and grade if it is displaced due to floating. Maintain the inside of the pipe free from foreign materials and in a clean and sanitary condition until its acceptance by the Owner.

C. Unless otherwise indicated, all specials shall be installed in full conformance with Section 33 11 11 - Steel Pipe, and other applicable sections of these Contract Documents.

END OF SECTION

SECTION 33 13 00
WATER PIPELINE TESTING AND DISINFECTION

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall perform flushing and testing of all pressure pipelines and appurtenant piping and disinfection of all pipelines and appurtenant piping for potable and fire water, complete.

B. This specification applies to all pipelines requiring hydrostatic tests (water medium) regardless of the pipeline service medium.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ANSI/AWWA B300	Hypochlorites
ANSI/AWWA B301	Liquid Chlorine
ANSI/AWWA C206	Field Welding of Steel Water Pipe
ANSI/AWWA C651	Disinfecting Water Mains

1.3 CONTRACTOR SUBMITTALS

A. A testing schedule, including proposed plans for water conveyance, control, disposal, and disinfection shall be submitted in writing for approval a minimum of 7 days before testing is to start.

B. A copy of the Utah Pollutant Discharge Elimination System (UPDES) permit application shall be submitted a minimum of 30 days prior to the proposed date to start testing. A copy of the approved UPDES permit shall be submitted prior to the start of testing.

C. Chlorine residual test data and bacteriological test data shall be submitted to document the results of the pipeline disinfection. Tests shall be conducted 24 hours after the start of disinfection.

PART 2 - PRODUCTS

2.1 MATERIALS REQUIREMENTS

A. All test equipment, chemicals for chlorination, temporary valves, bulkheads, or other water control equipment and materials shall be determined and furnished by the Contractor subject to the Engineer's review. No materials shall be used which would be injurious to the construction or its future function.

B. Used pressure gauges shall be recertified prior to testing.

C. Chlorine for disinfection shall be in the form of liquid chlorine, sodium hypochlorite solution, or calcium hypochlorite granules or tablets.

D. Liquid chlorine shall be in accordance with the requirements of ANSI/AWWA B301. Liquid chlorine shall be used only:
   1. In combination with appropriate gas flow chlorinators and ejectors;
   2. Under the direct supervision of an experienced technician;
   3. When appropriate safety practices are observed.

E. Sodium hypochlorite and calcium hypochlorite shall be in accordance with the requirements of ANSI/AWWA B300 - Hypochlorite.

PART 3 - EXECUTION

3.1 GENERAL

A. Water for testing and disinfecting water pipelines shall be furnished by the Contractor. The Contractor shall make all necessary provisions for conveying the water from the source to the points of use, and disposal of the water (and dechlorinating - where applicable).

B. All pressure pipelines shall be tested. Disinfection shall be accomplished by chlorination for all pipelines providing potable water or connected to a potable water system. All chlorinating and testing operations shall be performed in the presence of the Engineer.

C. Disinfection operations shall be scheduled as late as possible during the contract time period so as to assure the maximum degree of sterility of the facilities at the time the Work is accepted by the Owner. Samples for bacteriological testing shall be collected by the Contractor, and testing shall be performed by the Owner laboratory and at the expense of the Contractor. Results of the bacteriological testing shall be satisfactory with the State Department of Health or other appropriate regulatory agency.

D. Pipeline pressure tests will include the following tests:
   1. Air test of double welded lap joints.
   2. Hydrostatic pressure test of the complete pipeline, in segments as required to match pipe pressure class.
   3. Contractor shall conduct the discharge in accordance with the Utah Pollutant Discharge Elimination System (UPDES) permit from the Utah Division of Environmental Quality (UDEQ). The Contractor shall apply a reducing agent to the discharged water to neutralize the chlorine residual and meet the chlorine residual limit required under the permit. The Owner shall conduct the water quality sampling of the discharge as required by the permit. The Contractor shall notify local agencies, secure appropriate other permits and approvals, and provide erosion control measures for any releases as appropriate. Release of water after pipeline testing and disinfection have been completed shall be only if acceptable to the Engineer.

E. Notification: Notify the Engineer at each of the following stages:
   1. Three working days prior to the start of filling the pipeline with water.

2. Three working days prior to the start of chlorination.
3. Twenty-four hours before withdrawing samples for bacteriological testing.
4. Three working days prior to the start of flushing.

3.2 VISUAL INSPECTION

A. All welds shall be 100% visually inspected in accordance with ANSI/AWS D1.1, Table 6.1; Visual Inspection Acceptance Criteria for Statically Loaded Non-Tubular Connections.

3.3 AIR TEST

A. All double welded lap joint or double gasket Carnegie joint shall be pressure tested to a minimum of 40-psi air pressure for a period of 10 minutes per AWWA C206. No air leakage will be allowed.

B. If the test pressure drops below 40 psi, paint the welds with a soap solution. Mark any leaks indicated by the escaping gas bubbles.

C. Any joints which leak shall be repaired and retested.

3.4 HYDROSTATIC TESTING OF PIPELINES

A. Prior to hydrostatic testing, all pipelines shall be flushed or blown out as appropriate. Test all pipelines either in sections or as a unit. No section of the pipeline shall be tested until all field-placed concrete or mortar has attained an age of 14 days. The test shall be made by closing valves when available, or by placing temporary bulkheads in the pipe and filling the line slowly with water. The Contractor shall be responsible for ascertaining that all test bulkheads are suitably restrained to resist the thrust of the test pressure without damage to or movement of the adjacent pipe. Any unharnessed sleeve-type couplings, expansion joints, or other sliding joints shall be restrained or suitably anchored prior to the test, to avoid movement and damage to piping and equipment. Provide sufficient temporary air tappings in the pipelines to allow for evacuation of all entrapped air in each pipe segment to be tested. After completion of the tests, such taps shall be permanently plugged. Care shall be taken to see that all air vents are open prior to and during filling.

B. The pipeline shall be filled at a rate not to exceed 2-feet per second as calculated by using the cross-sectional area based on the inside diameter of the pipe and which will not cause any surges or exceed the rate at which the air can be released through the air valves at a reasonable velocity and all the air within the pipeline shall be properly purged. After the pipeline or section thereof has been filled, it shall be allowed to stand under a slight pressure for at least 24 hours to allow the concrete or mortar lining, as applicable, to absorb what water it will and to allow the escape of air from any air pocket. No personnel shall be within or enter any vault or confined space subject to flooding during the initial filling and for a 24 hour period. After the 24 hour period bulkheads, valves, and connections shall be examined for leaks. If leaks are found, corrective measures satisfactory to the Engineer shall be taken.

C. The hydrostatic test shall consist of holding the test pressure on the pipeline for a period of 4 hours. The test pressure for distribution and transmission pipelines shall be 150 percent of the working pressure in the pipeline measured at the lowest point of the pipeline section being tested. The test pressure for yard piping shall be as indicated on the Piping Schedule

measured at the lowest point of the pipeline section being tested. No pressure test will be required for a reservoir overflow line. All visible leaks shall be repaired in a manner acceptable to the Engineer.

D. The maximum allowable leakage for distribution and transmission pipelines shall be 10 U.S. gallons per inch of diameter per mile of pipe per 24 hours for pipe with 40-foot or greater lengths between joints and with rubber-gasketed joints and 20 U.S. gallons per inch of diameter per mile of pipe per 24 hours for pipe with 20-foot or less lengths between joints and with rubber-gasketed joints. The maximum leakage for yard piping shall be as shown on the Piping Schedule. Pipe with welded joints shall have no leakage.

E. In the case of pipelines that fail to pass the prescribed leakage test, determine the cause of the leakage, take corrective measures necessary to repair the leaks, and again test the pipelines at no additional cost to the Owner.

F. The pipeline shall be drained after successful completion of the hydrostatic test.

3.5 DISINFECTING PIPELINES

A. General: All potable water pipelines shall be disinfected in accordance with the requirements of ANSI/AWWA C651 - Disinfecting Water Mains as modified herein.

B. Prior to disinfecting the pipeline for potable water services and before placing into service for other water pipelines, flush the pipeline to remove any debris, rocks, or other foreign material that may have entered the pipe. Flushing shall be carried out such that the velocities in the pipe exceed 2.5 feet per second. Provide all required material, labor and equipment to complete flushing. Contractor shall provide the water for flushing. Make appropriate provision and preparations for disposal of flushing water, satisfying all local, state and federal rules, laws, regulations and ordinances.

C. Continuous Feed Method: Disinfect in accordance with ANSI/AWWA C651 except that:
   1. The water in the pipe shall contain 50 mg/l free chlorine.
   2. After 24 hours of disinfection, the residual free chlorine shall be at least 25 mg/l at the pipeline extremities.

D. Slug Feed Method: Disinfect in accordance with ANSI/AWWA C651.

E. Chlorinating Valves: During the process of chlorinating the pipelines, all valves and other appurtenances shall be operated while the pipeline is filled with the heavily chlorinated water.

F. Final Flushing: After the applicable retention period, the heavily chlorinated water shall be flushed from the pipeline until chlorine measurements show that the concentration in the water leaving the pipeline is no higher than that generally prevailing in the system or is acceptable for domestic use. If there is any question that the chlorinated discharge will cause damage to the environment, a reducing agent shall be applied to the water to neutralize thoroughly the chlorine residual remaining in the water. See the appendix of AWWA C651 for acceptable neutralization methods for heavily chlorinated water.

G. Sampling Ports: The Contractor shall provide sampling ports along the pipeline as defined in AWWA C651. Taps may be made at manways and air valves to help facilitate the spacing requirement.

H. Bacteriological Testing: After final flushing and before the pipeline is placed in service, two consecutive sets of samples shall be collected at least 24 hours apart by the Contractor from the end of the line and at other locations as designated by the Engineer, and shall be tested by the Owner for bacteriological quality in accordance with the requirements of AWWA C651. For this purpose, the pipe shall be refilled with fresh potable water and left for a period of 24 hours before any samples are collected. If the initial disinfection fails to produce satisfactory bacteriological results or if other water quality is affected, the new main may be reflushed and shall be resampled. If check samples also fail to produce acceptable results, the main shall be rechlorinated by the continuous-feed or slug method until satisfactory results are obtained – that being two consecutive sets of acceptable samples taken 24 hours apart.

3.6 CONNECTIONS TO EXISTING SYSTEM

A. Where connections are to be made to an existing potable water system, the interior surfaces of all pipe and fittings used in making the connections shall be swabbed or sprayed with a one percent hypochlorite solution before they are installed. Thorough flushing shall be started as soon as the connection is completed and shall be continued until discolored water is eliminated.

END OF SECTION

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SECTION 33 13 02
TESTING OF CONCRETE HYDRAULIC STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall perform all cleaning, flushing, and testing of all hydraulic structures and appurtenant piping complete, in accordance with the Contract Documents.

B. The Contractor shall be responsible for obtaining permits for discharging excess testing water if required to satisfy permit limits.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 20 – Submittal Procedures.

B. Submittals shall include:
   1. A testing plan and schedule, including methods for water conveyance, control, disposal, shall be submitted in writing for approval.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

A. Temporary valves, bulkheads, and other water control equipment and materials shall be as determined by the Contractor subject to the Engineer's review. No materials shall be used which would be injurious to the function of the structure.

PART 3 - EXECUTION

3.1 GENERAL

A. Water for testing will be furnished by the Owner; however, the Contractor shall convey the water from the Owner-designated source to the points of use.

B. All hydraulic structures and appurtenant pressure piping shall be tested; structures and piping used for potable water shall also be disinfected by chlorination. All chlorinating and testing operations shall be performed in the presence of the Engineer.

C. Membrane liner on interior vertical walls of concrete structures shall be installed prior to testing, but membrane liner on the floor shall be installed only after the structure has successfully passed the hydraulic tests.

D. Release of water from structures after testing has been completed shall comply with federal, state, and local regulations.

3.2 PRELIMINARY CLEANING AND FLUSHING

A. Prior to testing, hydraulic structures shall be cleaned by thoroughly hosing down all surfaces with a high pressure hose and nozzle of sufficient size to deliver a minimum flow of 50 gpm. Water, dirt, and foreign material accumulated in this cleaning operation shall be discharged from the structure or otherwise removed.

3.3 TESTING OF CONCRETE STRUCTURES

A. General: Testing shall be performed prior to backfilling. Testing shall not be performed sooner than 14 days after all portions of structure walls and associated roof systems have been completed.

B. Leakage Test and Repairs: After the structure has been filled, the leakage test shall be performed as follows:

1. The structure shall be filled to the maximum operating water level indicated on the Drawings, or if not indicated or if the level will be controlled by a weir, fill the structure to the weir level or to the overflow elevation, whichever is higher. The rate of filling shall not exceed 48 inches of depth per day.
2. Inspect the structure for visible leakage. Locations with any visible leakage, as evidenced by liquid droplets, flowing water, or moist areas on the outside surface which only could have originated from inside the structure, will be considered defective and shall be repaired before testing proceeds.
3. Measure and record initial water level readings at two locations that are approximately 180 degrees apart if the structure is circular or at opposite ends of the structure if the structure is rectangular.
4. Construct evaporation/precipitation devices as follows. A clear plastic calibrated open top container greater than 18-inches in diameter and in depth shall be partly filled with water, floated in the structure, and held in position at each measurement location but away from structure walls and items passing overhead such as beams or pipes. Measure the depth of water in the device.
5. Record the structure water levels and depths of water in the evaporation/precipitation devices at 24-hour intervals for a 7-day test period.
6. Each daily change in water surface elevation at each measurement point shall be adjusted by subtracting the change in water depth in the corresponding evaporation/precipitation device.
7. Acceptance Criteria: Both criteria apply.
    a. Allowable leakage
        1) Unlined concrete structures will pass the test if the water loss at the end of 7-days, as determined by averaging adjusted results at the two measurement locations, is equal to or less than 0.20 percent of the structure volume. Structures with multiple cells shall have the cells tested and evaluated individually.
        2) Lined concrete structures will pass the test if the water loss/gain at the end of 7-days equals that lost/gained due to evaporation/precipitation.
    b. No visible leakage appears during the 7-day test.
8. If intermediate readings or observed leakage indicate that the allowable leakage will be exceeded, the test may be terminated before the end of the 7-day period and

appropriate action taken to correct the problem before starting a new 7-day test period.

9. If the structure fails the test, the Contractor may at its option repeat the test or empty the structure as acceptable to the Engineer and examine the interior for evidence of any cracking or other conditions that might be responsible for the leakage. Cracks shall be "vee'd" and sealed with Xypex in accordance with Section 03 30 00 – Cast-In-Place Concrete. Each source of leakage shall be repaired on the water-holding side.
10. Following these operations, the Contractor shall again test the structure. The structure will not be accepted until the water loss leakage test is passed and all visible leakage repaired.

3.4 TESTING OF APPURTENANT PIPING

A. Piping appurtenant to hydraulic structures shall be tested in accordance with Section 33 13 00 – Water Pipeline Testing and Disinfection.

END OF SECTION

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SECTION 33 41 03
PVC NON-PRESSURE PIPE, RUBBER JOINTS

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide PVC non-pressure pipe and appurtenant work, complete and in place, in accordance with the Contract Documents.

B. This Section covers pipe from 4 to 48 inches diameter nominal size.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards:

ASTM D 1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM F 1803	Standard Specification for Poly (Vinyl Chloride)(PVC) Closed Profile Gravity Pipe and Fittings Based on Controlled Inside Diameter
ASTM D 2444	Test Method for Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
ASTM D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D 3034	Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and FittingsCement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
ASTM D 3212	Joints for Drain and Sewer Plastic Pipe Using Flexible Elastomeric Seals
ASTM F 477	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 679	Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Gravity Sewer Pipe and Fittings
ASTM F 794	Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F 913	Thermoplastic Elastomeric Seals (Gaskets) for Joining Plastic Pipe

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 20 – Contractor Submittals.

B. Shop Drawings: The Contractor shall submit shop drawings and laying diagrams of pipe, joints, bends, special fittings, and piping appurtenances.

C. Certificates: The Contractor shall submit manufacturer's certificate that pipe conforms to these specifications.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pipe shall be continuously and permanently marked with the manufacturer's name, pipe size, and minimum pipe stiffness in psi.

B. The Contractor shall also require the manufacturer to mark the date of extrusion on the pipe. This dating shall be done in conjunction with records to be held by the manufacturer for 2 years, covering quality control tests, raw material batch number, and other information deemed necessary by the manufacturer.

2.2 PIPE

A. Pipe shall conform to one of the following requirements
   1. Solid Wall Pipe (4" through 15") - ASTM D 3034, SDR 35.
   2. Solid Wall Pipe (18" through 48") -- ASTM F 679 – 46 psi.
   3. Ribbed Pipe (21" through 48") - ASTM F 794
   4. Closed Profile Wall Pipe (21" through 54") - ASTM F 1803 (Vylon or approved equal only)

B. Material for PVC pipe shall conform to the requirements of ASTM D 1784 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds, for cell classification 12454-C or 12364-A as defined therein. The manufacturer shall test a sample from each batch according to ASTM D 2444 - Test Method for Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight).

C. Joints shall conform to ASTM D 3212. Elastomeric seals for compression type joints shall conform to the requirements of ASTM F 477, ASTM F 913 - Thermoplastic Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

2.3 FITTINGS

A. All fittings shall be of the same material as the pipe, molded or formed to suit the pipe size and end design, in required configurations.

B. The stiffness of the fittings shall be not less than the stiffness of adjoining pipe.

PART 3 - EXECUTION

3.1 GENERAL

A. Laying, jointing, and testing for defects and for leakage shall be performed in the presence of the Engineer, and shall be subject to approval before acceptance. Material found to have defects will be rejected and the Contractor shall promptly remove such defective materials from the Site.

B. Installation shall conform to the requirements of ASTM D 2321, instructions furnished by the pipe manufacturer, and to the supplementary requirements herein. Wherever the provisions of this Section and the aforementioned requirements are in conflict, the more stringent provision shall apply.

3.2 HANDLING AND STORAGE

A. Handling
   1. Handling of the PVC pipe shall be done with implements, tools, and facilities as recommended by the pipe manufacturer to ensure that the pipe is not damaged in any manner during storage, transit, loading, unloading, and installation.
   2. Pipe shall be inspected both prior to and after installation in the trench and all defective lengths shall be rejected and immediately removed from the working area.
   3. Fittings shall be lowered into trench by means of rope, cable, chain, or other means without damage. Cable, rope, or other devices used for lowering fitting into trench, shall be attached around exterior of fitting for handling. Under no circumstances shall the cable, rope, or other device be attached through the fitting interior for handling or shall pipe or fittings be dropped or dumped into the trench.

B. Storage: Pipe should be stored, if possible, at the Site in unit packages provided by the manufacturer. Caution should be exercised to avoid compression damage or deformation to bell ends of the pipe. Pipe should be stored in such a way as to prevent sagging or bending and be protected from exposure to direct sunlight by covering with an opaque material while permitting adequate air circulation above and around the pipe. Gaskets should be stored in a cool, dark place out of the direct rays of the sun, preferably in original cartons.

3.3 TRENCHING AND BACKFILL

A. Trench excavation and backfill shall conform to the requirements of Section 31 23 00 – Earthwork and the Drawings.

3.4 LAYING PIPE

A. Pipe sections shall be closely jointed to form a smooth flow line. Immediately before placing each section of pipe in final position for jointings, the bedding for the pipe shall be checked for firmness and uniformity of slope.

B. Cutting and machining of the pipe shall be accomplished in accordance with the pipe manufacturer's standard procedures. Pipe shall not be cut with a cold chisel, standard iron pipe cutter, or any other method that may fracture the pipe or will produce ragged, uneven edges.

C. All foreign matter or dirt shall be removed from the interior of the pipe before lowering into position in the trench. Pipe shall be kept clean during and after laying. All openings in the pipe line shall be closed with water tight expandable type sewer plugs or PVC test plugs at the end of each day's operation or whenever the pipe openings are left unattended. The use of burlap, wood, or other similar temporary plugs will not be permitted.

D. Adequate protection and maintenance of all underground and surface utility structures, drains, sewers, and other obstructions encountered in the progress of the Work shall be the Contractor's responsibility.

E. Where the grade or alignment of the pipe is obstructed by existing utility structures such as conduits, ducts, pipes, branch connections to main sewers, or main drains, the obstruction shall be permanently supported, relocated, removed, or reconstructed by the Contractor in cooperation with owners of such utility structures. Unless otherwise indicated, protection of existing utility structures shall be the Contractor's responsibility.

3.5 FIELD JOINTING

A. Each pipe compression type joint shall be joined with a lock-in rubber ring and a ring groove that is designed to resist displacement during pipe insertion.

B. The ring and the ring seat inside the bell shall be wiped clean before the gasket is inserted. A thin film of lubricant shall be applied to the exposed surface of the ring and to the outside of the clean pipe end. Lubricant other than that furnished with the pipe shall not be used. The end of the pipe shall be then forced into the ring to complete the joint.

C. Fittings shall be carefully connected to pipe, and joint shall be checked to insure a sound and proper joint.

D. When pipe laying is not in progress, the open ends of the pipe shall be closed to prevent trench water from entering pipe. Adequate backfill shall be deposited on pipe to prevent floating of pipe. Any pipe which has floated shall be removed from the trench, cleaned, and relaid in an acceptable manner. No pipe shall be laid when, in the opinion of the Engineer, the trench conditions or weather are unsuitable.

3.6 SMALL DIAMETER LATERALS (SEWER LATERAL CONNECTIONS)

A. Laterals shall extend from the manhole, wye branch or similar fitting, as indicated in the Drawings. Wye fitting or other connection shall be positioned in the mainline such that it enters the mainline at an angle of at least 45 degrees from horizontal. Connections requiring a connection angle of less than 45 degrees shall be approved by the Engineer.

B. Install a 22.5 degree or 45 degree bend, or combination of bends, as required on the mainline wye to obtain the proper alignment and grade.

C. Lateral connections to manhole shall be made as directed in Section 33 05 16 – Precast Concrete Manholes and Vaults.

D. Laterals shall be installed along the indicated horizontal alignment with a uniform slope, free of low spots or adverse grades. Minimum slopes shall be 1/4 inch per foot for 4" diameter laterals and 1/8 inch per foot for 6" diameter laterals.

E. Cleanouts shall be installed on laterals at a horizontal spacing not to exceed 100 feet and at the locations indicated in the Drawings.

F. Any one bend (horizontal or vertical) shall not exceed 45 degrees and no more the two bends (horizontal or vertical) shall be installed without a cleanout.

G. Laterals shall be installed in accordance with all applicable requirements of the local plumbing codes.

3.7 INSTALLATION OF METALLIC LOCATING TAPE

A. Polyvinyl chloride pipelines shall be provided with a metallic locating tape laid along the centerline of the pipe trench at a depth of 18 inches below finished grade OR above top of pipe. The Contractor shall furnish manufacturer's literature, completely describing the tape proposed to be furnished. No tape shall be used prior to receipt of written approval of the Engineer.

3.8 TESTING

A. Field testing of gravity sewer pipe shall conform to the requirements of Section 33 08 00 – Gravity Piping Testing and Inspection.

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SECTION 33 41 05
DUCTILE IRON PIPE (AWWA C151, MODIFIED)

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall furnish and install ductile iron pipe and all appurtenant Work, complete in place, all in accordance with the requirements of the Contract Documents.

1.2 REFERENCE STANDARDS

A. Commercial Standards:

ANSI/AWWA C104/A21.4	Cement-Mortar Lining for Ductile Iron Pipe and Fittings for Water
ANSI/AWWA C105/A21.5	Polyethylene Encasement for Ductile Iron Piping and Fittings for Water
ANSI/AWWA C110/A21.10	Ductile Iron and Gray Iron Fittings, 3-in. through 48-in. for Water and Other Liquids
ANSI/AWWA C111/A21.11	Rubber-Gasket Joints for Ductile Iron and Gray Iron Pressure Pipe and Fittings
ANSI/AWWA C115/A21.15	Flanged Ductile Iron and Gray-Iron Pipe with Threaded Flanges
ANSI/AWWA C150/A21.50	Thickness Design of Ductile Iron Pipe
ANSI/AWWA C151/A21.51	Ductile Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids
ANSI/AWWA C153/A21.53	Ductile Iron Compact Fittings, 3-in. through 12-in. for Water and Other Liquids
AWWA C209	Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
ANSI/AWWA C600	Installation of Ductile Iron Water Mains and their Appurtenances
ASTM C150	Specification for Portland Cement

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings: The Contractor shall submit shop drawings of pipe and fittings in accordance with the requirements of Section 01 33 20 – Contractor Submittals, the requirements of the referenced standards and the following supplemental requirements as applicable and specified herein.
   1. Marking plan and details of standard pipe section showing dimensions, pipe joints, fitting and special fitting pressure rating and thickness, size, coating and lining data.
   2. Pipeline layout drawings showing the location of each pipe section, each special length, closure sections, location and angle of bends, outlets, location of valves, and other special fittings.

B. Certifications: The Contractor shall furnish a certified affidavit of compliance for all pipe and other products or materials furnished under this Section, as specified in the referenced standards and the following supplemental requirements:
   1. Physical and chemical properties.
      a. Hydrostatic Test Reports

C. Sample Costs: All expenses incurred in making samples for certification of tests shall be borne by the Contractor.

1.4 QUALITY ASSURANCE

A. Inspection: All pipe shall be subject to inspection at the place of manufacture, in accordance with the provisions of the referenced standards, as supplemented by the requirements herein. The Contractor shall notify the Engineer in writing of the manufacturing starting date not less than 14 calendar days prior to the start of any phase of the pipe manufacture.

B. During the manufacture of the pipe, the Engineer shall be given access to all areas where manufacturing is in process and shall be permitted to make all inspections necessary to confirm compliance with the Specifications.

C. Test: Except as modified herein, all materials used in the manufacture of the pipe shall be tested in accordance with the requirements of the referenced standards as applicable.

D. The Contractor shall perform said material tests at no additional cost to the Owner. The Engineer shall have the right to witness all testing conducted by the Contractor; provided, that the Contractor's schedule is not delayed for the convenience of the Engineer.

E. In addition to those tests specifically required, the Engineer may request additional samples of any material including lining and coating samples for testing by the Owner. The additional samples shall be furnished at no additional cost to the Owner

PART 2 - PRODUCTS

2.1 GENERAL

A. Standards: Mortar-lined and polyethylene-wrapped ductile iron pipe shall conform to ANSI/AWWA C151, C104, and C105, subject to the following supplemental requirements.

The pipe shall be of the diameter and class shown, shall be furnished complete with rubber gaskets as indicated in the Contract Documents, and all flanges, specials and fittings shall be provided as required under the Contract Documents.

B. Handling and Storage: The pipe shall be handled by devices acceptable to the Engineer, designed and constructed to prevent damage to the pipe coating/exterior. The use of equipment which might injure the pipe coating/exterior will not be permitted. Stockpiled pipe shall be suitably supported and shall be secured to prevent accidental rolling. All other pipe handling equipment and methods shall be acceptable to the Engineer.

C. Laying Lengths: Maximum pipe laying lengths shall be 20 feet with shorter lengths provided as required by the Drawings.

D. Finish: The pipe shall have smooth and dense interior surfaces, and shall be free from fractures, excessive interior surface crazing, and roughness.

E. Closures and Correction Pieces: Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing shown on the Drawings. The locations of correction pieces and closure assemblies are shown on the Drawings. Any change in location or number of said items shall be acceptable to the Engineer.

F. Pipe shall be new and recently manufactured. Refurbished pipe shall not be provided.

2.2 PIPE DESIGN CRITERIA

A. General: Ductile iron pipe shall be designed in accordance with the requirements of ANSI/AWWA C150 as applicable and as modified in this Section.

B. Pipe Wall Thickness for Internal Pressure: The pipe shall be designed with a net thickness to withstand the design pressure in accordance with the hoop stress formula.

C. Pipe Wall Thickness for External Load: The pipe shall also be designed with a net thickness to withstand internal loads using ANSI/AWWA C150 Design Equation (2) with the appropriate bending moment and deflection coefficients for Laying Condition Types 4 and 5 as applicable.

D. The pipe deflection shall be checked using ANSI/AWWA C150 Design Equation (3) and the coefficients stated above. The allowable deflection shall not exceed 0.0225 times the nominal diameter.

E. In lieu of ANSI/AWWA C150 Design Equation (4), the earth loads will be computed using the following two equations for trench or embankment loading as applicable:

1. Trench Condition:
   a. $W_d = C_d w B_d 2$,
   b. Where:
   c. W_d = Earth load in pounds per linear foot
   d. C_d = Calculation Coefficient
   e. Ku1 = 0.13
   f. w = 120 lb/ft3

g. B_d = Trench width at top of pipe, feet

2. Positive Projecting Embankment Condition:
   a. Wc = CcwBc2
   b. Where:
   c. Wc = Earth load in pounds per linear foot
   d. Cc = Calculation Coefficient (based on rsdP of 0.25)
   e. Ku1 = 0.13
   f. w = 120 lb/ft3
   g. Bc = Trench width at top of pipe, feet

F. The above two formulas are based on a depth of cover of 10 feet or greater. For depths of cover of less than 10 feet, HS-20 live load shall be included. For depths of cover of three feet or less, HS-20 live load plus impact shall be included. The determination of live load and impact factors shall be as recommend by AASHTO in "Standard Specifications for Highway Bridges."

G. If the calculated deflection, $Defl_x$, exceeds 0.0225 times the nominal diameter, the pipe class shall be increased.

H. Minimum Pipe Wall Thickness: In addition to the requirements of this Section, the minimum wall thickness shall be in accordance with Table 50.5 of ANSI/AWWA C150.

2.3 MATERIALS

A. Ductile Iron Pipe: Pipe materials shall conform to the requirements of ANSI/AWWA C151.

B. Cement: Cement for mortar lining shall conform to the requirements of ANSI/AWWA C104, provided that cement for mortar lining shall be Type V. A fly ash or pozzolan shall not be used as a cement replacement.

C. Polyethylene Sleeve: Material for the polyethylene sleeve shall conform to the requirements of ANSI/AWWA C105.

2.4 SPECIALS AND FITTINGS

A. Fittings for ductile iron pipe shall conform to the requirements of ANSI/AWWA C153/A21.53 or ANSI/AWWA C110/A21.10 for diameters 3-inch through 48-inch and shall have a minimum pressure rating of 250 psi. Ductile iron fittings larger than 48-inch shall conform to the above-referenced standard with the necessary modifications for the larger size.

2.5 DESIGN OF PIPE

A. General: The pipe furnished shall be ductile iron pipe, mortar-lined and polyethylene-wrapped with rubber-gasketed joints as shown.

B. Manufacturing Requirements: The pipe shall be designed, manufactured, tested, inspected, and marked according to applicable requirements previously stated and, except as hereinafter modified, shall conform to ANSI/AWWA C151.

C. Pipe Dimensions**:** The pipe shall be of the diameter and class shown. The minimum wall thickness for each pipe size shall be as specified or shown.

D. Fitting Dimensions: The fittings shall be of the diameter and class shown.

E. Joint Design: Ductile iron pipe and fittings shall be furnished with mechanical joints, push-on joints, flanged joints, and restrained joints as required.
   1. Mechanical and push-on joints shall conform to ANSI/AWWA C111/A21.11.
   2. Restrained Joint:
      a. Manufactured proprietary joint that mechanically restrains pipe to adjoining pipe without setscrews or devices with shoes or wedges activated by setscrews.
      b. The use of devices utilizing setscrews or with shoes or wedges activated by setscrews or bolts shall not be allowed. Except where allowed by governing agencies as temporary thrust restraint.
      c. The use of devices utilizing multiple gripping wedges incorporated into a follower gland meeting the requirements of ANSI/AWWA C110/A21.10.
      d. The use of devices utilizing setscrews shall not be allowed. Primary permanent restraint for all buried pipe fittings shall be accomplished using concrete thrust blocks. Temporary fitting restraint for testing of pipelines can be accomplished using mechanical thrust restraint utilizing multiple gripping wedges incorporated into a follower gland meeting the requirements of ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21/53. Temporary (or secondary) fitting restraint shall be in addition to primary permanent restraint. Permanent restraint for straight-run pipe joints can be accomplished using manufacturer's proprietary joint (e.g. Tyton Lock with Sure Stop gasket, or equal) or with mechanical joint restraints (e.g. EBAA Iron Megalug, or equal) utilizing multiple gripping wedges incorporated into a follower gland meeting the requirements of ANSI/AWWA C111/A21.11 or ANSI/AWWA C153/A21/53.
      e. Rated at minimum working pressure equal to or greater than that of the pipe class.
      f. The use of field-lock, gripper ring type restraining devices shall be limited to only locations where unforeseen field conditions or closure places require the pipe to be field fit, cut, and joined, and as approved by the Engineer. Where field locking, gripper ring type restraining devices are used, the gripper ring shall be installed a minimum of one full pipe length away from the fitting or closure. The installation of gripper ring type restraining devices where used shall be in strict accordance with the manufacturer's installation instructions.
      g. Field welding of ductile iron pipe and fitting shall not be allowed.
   3. Flanged joints shall conform to ANSI/AWWA C115/A21.15.

F. Joint Clearances: For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, will provide watertight joints under all operating conditions when properly installed. The Contractor shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted.

G. Coating and Linings Held Back: Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as shown, or as otherwise acceptable to the Engineer.

2.6 CEMENT-MORTAR LINING

A. Cement-Mortar Lining for Shop Application: Except as otherwise provided herein, interior surfaces of all ductile iron pipe, fittings and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with ANSI/AWWA C104. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or strutting. The lining machines shall be of a type that has been used successfully for similar work. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found faulty at the delivery site, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications.

B. Lining Thickness: The minimum lining thickness shall be as follows:

Nominal Pipe Diameter (in)	Minimum Lining Thickness (in)
3-12	1/8
14-24	3/16
30-54	1/4

C. Protection of Pipe Lining/Interior: All shop-applied cement mortar lining shall be given a water based (no-VOC) seal coat fully compliant with NSF61 standards and in conformance with ANSI/AWWA C104.

2.7 GLASS LINING

A. Pipe and fittings shall be glass lined where shown.

B. The glass lining shall be formulated for handling primarily sludge and scum. The formulation shall consist of special glasses and inorganic materials factory applied to chemically clean, gray iron. After application of the coating, the parts shall be placed in a specially designed furnace and brought up to temperature at which the glass melts and fuses to the base metal. Firing of the piece shall continue until fusion has completely taken place and the coating has an integral molecular bond with the metal.

C. The finished lining shall be from .008 to .012 inch thick. It shall have a hardness of from 5 to 6 mohs scale, and a density of from 2.5 to 3.0 grams per cubic centimeter as measured in accordance with ASTM D792. The glass shall be capable of withstanding thermal shock of 3560 degrees F without crazing, blistering, or spalling. There shall be no visible loss of surface gloss in the lining after immersion of a normal production run sample in an 8 percent sulfuric acid solution at 148 degrees F for a period of 10 minutes. In addition, when testing in accordance with ASTM C283, it shall show a weight loss of not more than 3 milligrams per square inch.

D. Factory assembled flanges on spool pieces shall be screwed on, unless otherwise specified. Bolt holes and flange faces shall be aligned before glassing. The pieces shall be sealed and tested prior to shipment.

E. The glass lining shall be in accordance with the manufacturer's standard tolerances for coverage, continuity, and gloss. Pinholes, crazing, or fishscales which substantially expose the metal substrate shall be cause for rejection of the piece. Sizes, details, handling, stacking, etc. shall be in accordance with the manufacturer's recommendations.

F. Glass lining shall be Ferrock lining as manufactured by Ferro Enameling, Permutit SG-14 as manufactured by the Permutit Company, Bulwark Corporation, or approved equal.

2.8 EXTERIOR COATING OF PIPE

A. Exterior Coating of Exposed Piping: The exterior surfaces of pipe which will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of rust-inhibitive primer conforming to the requirements of Section 09 90 00 – Painting and Coating.

B. Exterior Coating of Buried Piping: The exterior coating shall be an asphaltic coating approximately one mil thick.

2.9 SOURCE QUALITY CONTROL

A. Factory Tests: In accordance with AWWA C104, C105, C110, C111, C115, C150, C151, C153, and C606.

PART 3 - EXECUTION

3.1 GENERAL

A. Laying, jointing, testing for defects and for leakage shall be performed in the presence of the Engineer, and shall be subject to approval before acceptance. Material found to have defects will be rejected and the Contractor shall promptly remove such defective materials from the Site.

B. Installation shall conform to the requirements of AWWA C600, instructions furnished by the pipe manufacturer, and to the supplementary requirements herein. Wherever the provisions of this Section and the aforementioned requirements are in conflict, the more stringent provision shall apply.

3.2 INSTALLATION OF PIPE

A. Handling and Storage: All pipe, fittings, etc., shall be carefully handled and protected against damage, impact shocks, and free fall. All pipe handling equipment shall be acceptable to the Engineer. Pipe shall not be placed directly on rough ground but shall be supported in a manner that will protect the pipe coating against injury whenever stored at the trench site or elsewhere. No pipe shall be installed where the lining or coating show defects that may be harmful as determined by the Engineer. Such damaged lining or coating shall be repaired, or a new undamaged pipe shall be furnished and installed.

B. Damaged Pipe: All pipe damaged prior to Substantial Completion shall be repaired or replaced by the Contractor.

C. Contractor to Inspect Pipe: The Contractor shall inspect each pipe and fitting prior to installation to insure that there are no damaged portions of the pipe.

D. Trench excavation and backfill shall conform to the requirements of Section 31 23 00 – Earthwork. Care shall be taken to ensure that pipe zone material is compacted and in full contact with the haunches of the pipe and that the pipe is fully supported.

E. Clean Pipe: Before placement of pipe in the trench, each pipe or fitting shall be thoroughly cleaned of any foreign substance, which may have collected thereon, and shall be kept clean at all times thereafter. For this purpose, the openings of all pipes and fittings in the trench shall be closed during any interruption to the Work.
   1. Remove lumps, blisters, and excess asphaltic type coating from bell and spigot ends of each pipe. Wire brush outside of spigot and inside of bell and wipe clean, dry, and free from oil and grease before pipe is laid.
   2. Wipe ends of mechanical joint pipe and fittings and of rubber gasket joint pipe and fittings clean of dirt, grease, and foreign matter.

F. Pipe Laying: The pipe shall be installed in accordance with ANSI/AWWA C600.
   1. Direction of Laying: Lay pipe with bell end facing in direction of laying. For lines on an appreciable slope, face bells upgrade at discretion of Engineer.
   2. Mechanical Joint, Push-On Joint, and Restrained Joint Pipe: After first length of pipe is installed in trench, secure pipe in place with approved backfill material tamped under and along sides to prevent movement. Keep ends clear of backfill. After each section is jointed, place backfill as specified to prevent movement. For restrained joint pipe and fittings, after each section is jointed and restraining devices are completely installed, fully extend the completed joint and place backfill as specified to prevent movement before installation of the next section of pipe or fitting.
   3. Take precautions necessary to prevent floating of pipe prior to completion of backfill operation.
   4. When using movable trench shield, take necessary precautions to prevent pipe joints from pulling apart when moving shield ahead.
   5. Do not allow foreign material to enter pipe while it is being placed in trench.
   6. Close and block open end of last laid section of pipe to prevent entry of foreign material or creep of gasketed joints when laying operations are not in progress, at close of day's work, or whenever workers are absent from job.

G. Joining Push-On Joint Pipe and Mechanical Joint Fittings:
   1. Join pipe with push-on joints and mechanical joint fittings in strict accordance with manufacturer's recommendations.
   2. Provide special tools and devices, such as, special jacks, chokers, and similar items required for installation.
   3. Lubricate pipe gaskets using lubricant furnished by pipe manufacturer. No substitutes will be permitted.
   4. Clean ends of fittings of dirt, mud, and foreign matter by washing with water and scrubbing with a wire brush, after which, slip gland and gasket on plain end of pipe. If necessary, lubricate end of pipe to facilitate sliding gasket in place, then guide fitting onto spigot of pipe previously laid.

H. Founding Pipe: Pipe shall be laid directly on the Pipe Zone material. No blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe. Excavations shall be made as needed to facilitate removal of handling devices after the pipe is laid. Bell holes shall be formed at the ends of the pipe to prevent point loading at the bells or couplings. Excavation shall be made as needed outside the normal trench section at field joints to permit adequate access to the joints for field connection operations and for application of coating on field joints.

I. Unforeseen Obstructions: Where necessary to raise or lower the pipe due to unforeseen obstructions or other causes, the Engineer may change the alignment and/or the grades. Such change shall be made by the deflection of joints, or by the use of additional fittings. However, in no case shall the deflection in the joint exceed the maximum designed deflection recommended by the pipe manufacturer. No joint shall be misfit any amount that will be detrimental to the strength and water tightness of the finished joint.

J. Except for short runs which may be permitted by the Engineer, pipes shall be laid uphill on grades exceeding 10 percent. Pipe which is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement. All bends shall be properly installed as shown.

K. Cold Weather Protection: No pipe shall be installed upon a foundation into which frost has penetrated or at any time that there is a danger of the formation of ice or penetration of frost at the bottom of the excavation. No pipe shall be laid unless it can be established that the trench will be backfilled before the formation of ice and frost occurs.

L. Pipe and Specials Protection: The openings of all pipe and specials shall be protected with suitable bulkheads to prevent unauthorized access by persons, animals, water or any undesirable substance. At all times, means shall be provided to prevent the pipe from floating.

M. Pipe Cleanup: As pipe laying progresses, the Contractor shall keep the pipe interior free of all debris. The Contractor shall completely clean the interior of the pipe of all sand, dirt, mortar splatter and any other debris following completion of pipe laying, pointing of joints and any necessary interior repairs prior to testing and disinfecting the completed pipeline.

N. Cutting Pipe: General: Cut pipe for inserting closure pieces in a neat and workmanlike manner without damaging pipe or lining and so as to leave a smooth end, at right angles to axis of pipe.
   1. Pipe: Cut pipe with milling type cutter or saw. Do not flame cut.
   2. Dressing Cut Ends: Dress cut ends of push-on joint pipe by beveling, as recommended by manufacturer.

O. Field Welding:
   1. Field welding of ductile iron pipe shall not be allowed.
   2. Field welding of bars for restrained joint systems will not be allowed. All welding shall be performed in pipe manufacturer's shop.

P. Field Installed Outlets: Field outlets may be installed with a saddle; however, the maximum nominal diameter of outlet for saddle shall be 2-inch. Opening in pipe shall be machine cut. Flame cut openings shall not be allowed.

3.3 RUBBER GASKETED JOINTS

A. Rubber Gasketed Joints: Immediately before jointing pipe, the bell end of the pipe shall be thoroughly cleaned, and a clean rubber gasket, lubricated with an approved vegetable-based lubricant, shall be placed in the bell groove. The spigot end of the pipe shall be carefully cleaned and lubricated with a vegetable-based lubricant. The spigot end of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position. Tilting of the pipe to insert the spigot into the bell will not be permitted.

3.4 CORROSION PROTECTION

A. Polyethylene Encasement: Buried ductile iron pipe shall be polyethylene encased in accordance with the requirements of ANSI/AWWA C105/A21.5.
   1. Encase pipe, fittings, and valves in accordance with AWWA C105, Method A.
   2. Cut polyethylene tube approximately 2 feet longer than pipe length.
   3. Slip tube around pipe, centering to provide 1-foot overlap on each adjacent section.
   4. Pull encasement to take out slack and wrap snug around pipe.
   5. Secure overlap in place and fold at quarter points of pipe length.
   6. Wrap and tape encasement snug around fittings and valves.

3.5 INSTALLATION OF PIPE APPURTENANCES

A. Protection of Appurtenances: Where the joining pipe is tape-coated, buried appurtenances shall be coated with cold-applied tape in accordance with ANSI/AWWA C209, Type II. Where pipe is encased in polyethylene sleeves, buried appurtenances shall also be encased in polyethylene.

B. Installation of Valves: All valves shall be handled in a manner to prevent any injury or damage to any part of the valve. All joints shall be thoroughly cleaned and prepared prior to installation. The Contractor shall adjust all stem packing and operate each valve prior to installation to insure proper operation.

C. Valve Installation: All valves shall be installed so that the valve stems are plumb and in the location shown on the Drawings.

3.6 INSTALLATION OF METALLIC LOCATING TAPE

A. Buried pipelines shall be provided with a metallic locating tape laid along the centerline of the pipe trench at a depth of 18 inches below finished grade OR above top of pipe. The Contractor shall furnish manufacturer's literature, completely describing the tape proposed to be furnished. No tape shall be used prior to receipt of written approval of the Engineer.

3.7 FIELD TESTING AND DISINFECTION

A. Field testing shall conform to the requirements of Section 33 13 00 – Water Pipeline Testing and Disinfection as applicable.

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PROCESS INTEGRATION

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SECTION 40 05 00
PIPING, GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall furnish and install all piping systems shown and specified, in accordance with the requirements of the Contract Documents. Each system shall be complete with all necessary fittings, hangers, supports, anchors, seismic restraints, expansion joints, flexible connectors, valves, accessories, heat tracing, insulation, lining and coating, testing, disinfection, excavation, backfill and encasement, to provide a functional installation.

B. The piping shown is intended to define the general layout, configuration, routing, method of support, pipe size, and pipe type. The mechanical drawings are not pipe construction or fabrication drawings. It is the Contractor's responsibility to develop the details necessary to construct all mechanical piping systems, to accommodate the specific equipment provided, and to provide and install all spools, spacers, adapters, connectors, etc., for a complete and functional system.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ANSI/ASME B1.20.1	Pipe Threads, General Purpose (inch)
ANSI B16.5	Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and other Special Alloys
ANSI/AWWA C207	Steel Pipe Flanges for Water Works Service, Sizes 4 in through 144 in.
ANSI/AWWA C606	Grooved and Shouldered Joints
ANSI/AWS D1.1	Structural Welding Code
ASTM A 307	Specification for Carbon Steel Bolts and Studs, 6,000 psi Tensile
ASTM A 325	Specification for High-Strength Bolts for Structural Steel Joints
ASTM D 792	Test Methods for Specific Gravity and Density of Plastics by Displacement
ASTM D 2000	Classification System for Rubber Products in Automotive Applications

1.3 CONTRACTOR SUBMITTALS

A. Submit complete shop drawings and certificates, test reports, affidavits of compliance, of all piping systems, in accordance with the requirements in Section 01 33 20 – Submittal Procedures, and as indicated in the individual piping sections. The shop drawings shall include all necessary dimensions and details on pipe joints, fittings, fitting specials, valves, appurtenances, design calculations, and material lists. The submittals shall include detailed layout, spool, or fabrication drawings which show all pipe spools, spacers, adapters, connectors, fittings, and pipe supports and seismic restraints necessary to accommodate the equipment and valves provided in a complete and functional system.

B. All expenses incurred in making samples for certification of tests shall be borne by the Contractor at no increased cost to the Owner.

C. Submit as part of the shop drawings a statement from the pipe fabricator certifying that all pipes will be fabricated subject to a recognized Quality Control Program. An outline of the program shall be submitted to the Engineer for review prior to the fabrication of any pipe.

1.4 QUALITY ASSURANCE

A. Inspection: All pipe shall be subject to inspection at the place of manufacture. During the manufacture of the pipe, the Engineer shall be given access to all areas where manufacturing is in progress and shall be permitted to make all inspections necessary to confirm compliance with the Specifications.

B. Tests: Except where otherwise indicated, all materials used in the manufacture of the pipe shall be tested in accordance with the applicable specifications and standards. Welds shall be tested as indicated. Perform all tests at no additional cost to the Owner.

C. Welding Requirements: All welding procedures used to fabricate pipe shall be prequalified under the provisions of ANSI/AWS D1.1. Welding procedures shall be required for, but not necessarily limited to, longitudinal and girth or spiral welds for pipe cylinders, spigot and bell ring attachments, reinforcing plates and ring flange welds, and plates for lug connections.

D. Welder Qualifications: All welding shall be done by skilled welders, welding operators, and tackers who have had adequate experience in the methods and materials to be used. Welders shall be qualified under the provisions of ANSI/AWS D1.1 by an independent local, approved testing agency not more than 6 months prior to commencing Work on the pipeline. Machines and electrodes similar to those used in the Work shall be used in qualification tests. Furnish all material and bear the expense of qualifying welders at no increased cost to the Owner.

E. NSF/ANSI 61 for Drinking Water System Components: All materials that will contact potable water shall comply with the requirements of the NSF/ANSI 61 Standard.

1.5 MANUFACTURER'S SERVICE REPRESENTATIVE

A. Where the assistance of a manufacturer's service representative is advisable, in order to obtain perfect pipe joints, supports, or special connections, furnish such assistance at no additional cost to the Owner.

1.6 MATERIAL DELIVERY, STORAGE, AND PROTECTION

A. All piping materials, fittings, valves, and accessories shall be delivered in a clean and undamaged condition and stored off the ground, to provide protection against oxidation caused by ground contact. All defective or damaged materials shall be replaced with new materials.

1.7 CLEANUP

A. After completion of the Work, all remaining pipe cuttings, joining and wrapping materials, and other scattered debris, shall be removed from the site. The entire piping system shall be handed over in a clean and functional condition.

PART 2 - PRODUCTS

2.1 GENERAL

A. All pipes, fittings, and appurtenances shall be furnished in accordance with the requirements of the applicable Sections of Division 33 and this Section.

B. Miscellaneous Small Pipes: Miscellaneous small pipes and fittings shall be provided by the Contractor in accordance with the requirements of Section 40 00 03 - Mill Piping - Exposed and Buried and this Section.

C. Pipe Supports: All pipes shall be adequately supported in accordance with the requirements of Section 40 05 07 - Pipe Supports, and as indicated.

D. Lining: All requirements pertaining to thickness, applications, and curing of pipe lining, are in accordance with the requirements of the applicable Sections of Division 33, unless otherwise indicated.

E. Coating: All requirements pertaining to thickness, application, and curing of pipe coating, are in accordance with the requirements of the applicable Sections of Division 33, unless otherwise indicated. Pipes above ground or in structures shall be field-painted in accordance with Section 09 97 01 - Pipeline Coating and Linings or 09 99 90 – Paintings and Coatings.

F. Pressure Rating: All piping systems shall be designed for the maximum expected pressure as defined in Section 33 13 00 - Water Pipeline Testing and Disinfection, or as indicated on the piping schedule.

G. Grooved Piping Systems: Piping systems with grooved joints and fittings may be provided, if approved by the Engineer, in lieu of screwed, flanged, welded, or mechanical joint systems for steel and ductile iron yard piping above and below ground within the property limits of pump stations, and similar installations. All grooved couplings on buried piping must be bonded. To assure uniform and compatible piping components, all grooved fittings, couplings, and valves shall be from the same manufacturer. The Contractor shall make the coupling manufacturer responsible for the selection of the correct style of coupling and gasket for each individual location.

2.2 PIPE FLANGES

A. Flanges: Where the design pressure is 150 psi or less, flanges shall conform to either ANSI/AWWA C207 Class D or ANSI B16.5 150-pound class. Where the design pressure is greater than 150 psi, up to a maximum of 275 psi, flanges shall conform to either ANSI/AWWA C207 Class E, Class F, or ANSI B16.5 150-pound class. However, AWWA flanges shall not be exposed to test pressures greater than 125 percent of rated capacity. For higher test pressures, the next higher rated AWWA flange or an ANSI-rated flange shall be selected. Where the design pressure is greater than 275 psi up to a maximum of 700 psi, flanges shall conform to ANSI B16.5 300-pound class. Flanges shall have flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise shown. Attachment of the flanges to the pipe shall conform to the applicable requirements of ANSI/AWWA C207. Flanges for miscellaneous small pipes shall be in accordance with the standards specified for these pipes.

B. Blind Flanges: Blind flanges shall be in accordance with ANSI/AWWA C207, or with the standards for miscellaneous small pipes. All blind flanges for pipe sizes 12 inches and over shall be provided with lifting eyes in form of welded or screwed eye bolts.

C. Flange Coating: All machined faces of metal blind flanges and pipe flanges shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is completed.

D. Flange Bolts: Contractor shall supply all bolts and nuts in conformance with Section 05 50 00 – Metal Fabrications. Studs and bolts shall extend through the nuts a minimum of 1/4 inch. All-thread studs shall be used on all valve flange connections, where space restrictions preclude the use of regular bolts.

E. Insulating Flanges: Insulated flanges shall have bolt holes 1/4 inch diameter greater than the bolt diameter.

F. Insulating Flange Sets: Insulating flange sets shall be provided by the Contractor where shown. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers and a steel washer. Insulating sleeves and washers shall be one piece when flange bolt diameter is 1-1/2 inches or smaller and shall be made of acetal resin. For bolt diameters larger than 1-1/2 inches, insulating sleeves and washers shall be two-piece and shall be made of polyethylene or phenolic. Steel washers shall be in accordance with ASTM A 325. Insulating gaskets shall be full-face.

G. Insulating Flange Manufacturers, or Equal
   1. JM Red Devil, Type E
   2. Maloney Pipeline Products Co., Houston
   3. PSI Products, Inc., Burbank, California.

H. Flange Gaskets: Contractor shall provide flange gaskets for all pipe flanges. Gaskets for flanged joints shall be full-faced, 1/16-inch thick compressed sheets of asbestos-free aramid fiber base, with nitrile binder and nonstick coating, suitable for temperatures to 700 degrees F, a pH of 1 to 11, and pressures to 1,000 psig. Blind flanges shall have gaskets covering the

entire inside face of the blind flange and shall be cemented to the blind flange. Ring gaskets shall not be permitted.

I. Flange Gasket Manufacturers, or Equal
   1. John Crane, Style 2160.
   2. Garlock, Style 3000

2.3 THREADED INSULATING CONNECTIONS

A. General: Threaded insulating bushings, unions, or couplings, as appropriate, shall be used for joining threaded pipes of dissimilar metals and for piping systems where corrosion control and cathodic protection are involved.

B. Materials: Threaded insulating connections shall be of nylon, Teflon, polycarbonate, polyethylene, or other nonconductive materials, and shall have ratings and properties to suit the service and loading conditions.

2.4 MECHANICAL-TYPE COUPLINGS (GROOVED OR BANDED PIPE)

A. Construction: Cast mechanical-type couplings shall be provided where shown. The couplings shall conform to the requirements of ANSI/AWWA C606. Bolts and nuts shall conform to the requirements of Section 05 50 00 – Metal Fabrications. All gaskets for mechanical-type couplings shall be compatible with the piping service and fluid utilized, in accordance with the coupling manufacturer's recommendations. The wall thickness of all grooved piping shall conform with the coupling manufacturer's recommendations to suit the highest expected pressure. To avoid stress on equipment, all equipment connections shall have rigid-grooved couplings, or harness sets in sizes where rigid couplings are not available, unless thrust restraint is provided by other means. The Contractor shall have the coupling Manufacturer's service representative verify the correct choice and application of all couplings and gaskets, and the workmanship, to assure a correct installation.

B. Couplings for Steel Pipe, Manufacturers, or Equal
   1. Victaulic Style 44 with Type D Heavy Duty Grooved Adaptor Ends.

C. Ductile Iron Pipe Couplings, Manufacturers, or Equal
   1. Gustin-Bacon.
   2. Victaulic Style 31 (flexible or rigid grooving).
   3. Note: Ductile iron pipe couplings shall be furnished with flush seal gaskets.

D. Couplings for PVC Pipe, Manufacturers, or Equal
   1. Gustin-Bacon.
   2. Victaulic Style 775.
   3. Note: Couplings for PVC pipe shall be furnished with radius cut or standard roll grooved pipe ends. Grooved end couplings shall be used on PVC pipe only for Schedule 80 vent piping at the vaults. Grooved end couplings shall not be used for PVC C905 water pipe.

2.5 SLEEVE-TYPE COUPLINGS

A. Construction: Sleeve-type couplings shall be provided where indicated, in accordance with ANSI/AWWA C219 unless otherwise indicated, and shall be of steel with steel bolts, without pipe stop, and shall be of sizes to fit the pipe and fittings. The middle ring shall be not less than 1/4 inch in thickness and shall be either 5 or 7 inches long for sizes up to and including 30 inches and 10 inches long for sizes greater than 30 inches, for standard steel couplings, and 16 inches long for long-sleeve couplings. The followers shall be single-piece contoured mill section welded and cold-expanded as required for the middle rings. They shall be of sufficient strength to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling. The shape of the follower shall be of such design as to provide positive confinement of the gasket. Bolts and nuts shall conform to the requirements of Section 05 50 00 – Metal Fabrications. Buried sleeve-type couplings shall be epoxy-coated at the factory.

B. Pipe Preparation: The ends of the pipe, where indicated, shall be prepared for flexible steel couplings. Plain ends for use with couplings shall be smooth and round for a distance of 12 inches from the ends of the pipe, with outside diameter not more than 1/64 inch smaller than the nominal outside diameter of the pipe. The middle ring shall be tested by cold-expanding a minimum of one percent beyond the yield point, to proof-test the weld to the strength of the parent metal. The weld of the middle ring shall be subjected to air test for porosity.

C. Gaskets: Gaskets for sleeve-type couplings shall be rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions. Gaskets for wastewater and sewerage applications shall be Buna "N," grade 60, or equivalent suitable elastomer.
   1. The rubber in the gasket shall meet the following specifications:
      a. Color - Jet Black.
      b. Surface - Nonblooming.
      c. Durometer Hardness - 74 " 5.
      d. Tensile Strength - 1,000 psi Minimum.
      e. Elongation - 175 percent Minimum.
   2. The gaskets shall be immune to attack by impurities normally found in water or wastewater. All gaskets shall meet the requirements of ASTM D 2000, AA709Z, meeting Suffix B13 Grade 3, except as noted above. All gaskets shall be compatible with the piping service and fluid utilized.

D. Insulating Couplings: Where insulating couplings are required, both ends of the coupling shall have a wedge-shaped gasket which assembles over a rubber sleeve of an insulating compound in order to obtain insulation of all coupling metal parts from the pipe.

E. Restrained Joints: All sleeve-type couplings on pressure lines shall be harnessed unless thrust restraint is provided by other means. Harnesses shall be in accordance with the requirements of the appropriate reference standard, or as shown.

F. Manufacturers, or Equal
   1. Dresser, Style 38.
   2. Ford Meter Box Co., Inc., Style FC1 or FC3.
   3. Smith-Blair, Style 411.

4. Baker, Series 200

2.6 FLANGED END CONNECTORS

A. Flanged coupling adapters, shall be in accordance with AWWA C219.

B. Dismantling joints for connecting flanged pipe shall be AWWA C219 compliant. Provide studs and nuts to seal gasket separate and independent from tie-bar restraint system.

C. All dismantling joints shall be the restrained type per AWWA M-11. Tie-bar restraint system shall conform to ASTM A193-B7 per AWWA M-11 and be designed to withstand the test pressure shown on the Drawings.

D. All dismantling joints shall use standard flanges in accordance with AWWA C207. The thickness of the dismantling joint flanges shall be equal to or greater than the class of flange that is connected to as required by the test pressure as shown on the drawings. Buried flanges shall be wrapped with petroleum was tape per AWWA C217.

E. Manufacturers, or Equal
1. Smith-Blair, Style 972 or 975
2. Baker, Series DJ

2.7 FLEXIBLE CONNECTORS

A. Flexible connectors shall be installed in all piping connections to engines, blowers, compressors, and other vibrating equipment, and where shown. Flexible connectors for service temperatures up to 180 degrees F shall be flanged, reinforced Neoprene or Butyl spools, rated for a working pressure of 40 to 150 psi, or reinforced, flanged duck and rubber, as best suited for the application. Flexible connectors for service temperatures above 180 degrees F shall be flanged, braided stainless steel spools with inner, annular, corrugated stainless steel hose, rated for minimum 150 psi working pressure, unless otherwise shown. The connectors shall be 9 inches long, face-to-face flanges, unless otherwise shown. The final material selection shall be approved by the manufacturer. Submit manufacturer's shop drawings and calculations.

2.8 EXPANSION JOINTS

A. All piping subject to expansion and contraction shall be provided with sufficient means to compensate for such movement, without exertion of undue forces to equipment or structures. This may be accomplished with expansion loops, bellow-type expansion joints, or sliding-type expansion joints. Expansion joints shall be of stainless steel, monel, rubber, or other materials, best suited for each individual service. Submit detailed calculations and manufacturer's shop drawings, guaranteeing satisfactory performance of all proposed expansion joints, piping layouts showing all anchors and guides, and information on materials, temperature and pressure ratings.

2.9 PIPE THREADS

A. All pipe threads shall be in accordance with ANSI/ASME B1.20.1.

2.10 AIR AND GAS TRAPS

A. Air and gas pipes shall be sloping to low points, provided with drip legs, shutoff valves, strainers and traps. The traps shall be piped to the nearest drain. Air and gas traps shall be not less than 150-pound iron body float type with copper or stainless steel float. Bracket, lever, and pins shall be of stainless steel. Drain traps shall have threaded connections.

B. Manufacturers, or Equal
   1. Armstrong Machine Works.
   2. Spirax Sarco, Inc.

PART 3 - EXECUTION

3.1 GENERAL

A. All pipes, fittings, and appurtenances shall be installed in accordance with the requirements of the applicable Sections of Division 33. The lining manufacturer shall take full responsibility for the complete, final product and its application. All pipe ends and joints at screwed flanges shall be epoxy-coated, to assure continuous protection.

B. Where core drilling is required for pipes passing through existing concrete, core drilling locations shall be determined by radiograph of concrete construction to avoid damage to embedded raceways and rebars.

C. Flanges shall be installed at least 6-inches from a wall. Fittings shall be installed with sufficient clearance for maintenance and removal and reinstallation.

3.2 FIELD TESTING

A. All piping shall be tested in accordance with applicable standards and the contract documents.

END OF SECTION

SECTION 40 05 07
PIPE SUPPORTS

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall provide pipe supports, seismic restraints, hangers, guides, and anchors, complete, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be in accordance with Section 01 33 20 - Contractor Submittals.

B. Shop Drawings: Shop drawings shall include the following information:
   1. Drawings of pipe supports, restraints, hangers, anchors, and guides
   2. Calculations for special supports and anchors.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Code Compliance: Piping systems and pipe connections to equipment shall be properly anchored and supported to prevent undue deflection, vibration, dislocation due to seismic events and line pressures, and stresses on piping, equipment, and structures. Supports and parts thereof shall conform to the requirements of ASME B31.1 – Power Piping, except as supplemented or modified below. Supports for plumbing piping shall be in accordance with the latest edition of the applicable plumbing code or local administration requirements.

B. Structural Members: Wherever possible, pipes shall be supported from structural members. Where it is necessary to frame structural members between existing members, such supplementary members shall be provided at no additional cost to the Owner. All supplementary members shall be in accordance with the requirements of the building code and the American Institute of Steel Construction and shall be acceptable to the Engineer.

C. Pipe Hangers: Pipe hangers shall be capable of supporting the pipe in all conditions of operation, allowing free expansion and contraction of the piping, and preventing excessive stress on equipment. Hangers shall have a means of vertical adjustment after erection. Hangers shall be designed to prevent becoming disengaged by any movement of the supported pipe. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves, shall include hydraulic shock suppressors. Hanger rods shall be subject to tensile loading only.

D. Hangers Subject to Horizontal Movements: At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit such movement. Where horizontal pipe movement is greater than 1/2-inch, or where the hanger rod deflection from the vertical is greater than 4 degrees from the cold to the hot position of the pipe, the hanger

rod and structural attachment shall be offset in such a manner that the rod is vertical in the hot position.

E. Spring-Type Hangers: Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping. Spring-type hangers shall be sized to the manufacturer's printed recommendations and the loading conditions encountered. Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicate at all times the compression of the spring. Supports shall be capable of accommodating at least four times the maximum travel due to thermal expansion.

F. Thermal Expansion: Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or joints shall be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints permitting the piping to expand and contract freely in directions away from the anchored points. Components shall be structurally suitable to withstand loads imposed.

G. Heat Transmission: Supports, hangers, anchors, and guides shall be so designed and insulated, that excessive heat will not be transmitted to the structure or to other equipment.

H. Riser Supports: Where practical, risers shall be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.

I. Freestanding Piping: Free-standing pipe connections to equipment such as chemical feeders and pumps shall be firmly attached to steel frames fabricated from angles, channels, or I-beams anchored to the structure. Exterior, free-standing overhead piping shall be supported on fabricated pipe stands consisting of pipe columns anchored to concrete footings, with horizontal, welded steel angles and U-bolts or clamps securing the pipes.

J. Materials of Construction:
   1. General: Pipe support assemblies, including framing, hardware, and anchors, shall be steel construction, galvanized after fabrication, unless otherwise indicated.
   2. Submerged Supports: Submerged piping, as well as piping, conduits, and equipment in hydraulic structures within 24 inches of the water level, shall be supported with support, assemblies, including framing, hardware, and anchors, constructed of Type 316 stainless steel, unless otherwise indicated.
   3. Corrosive: Piping in chemical and corrosive areas shall be supported with support assemblies, including framing, hardware, and anchors, constructed of Type 316 stainless steel or FRP, unless otherwise indicated.

K. Point Loads: Any meters, valves, heavy equipment, and other point loads on PVC, FRP, and other plastic pipes, shall be supported on both sides, according to manufacturer's recommendations to avoid undue pipe stresses and failures. To avoid point loads, all supports on PVC, FRP, and other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields.

L. Noise Reduction: To reduce transmission of noise in piping systems, copper tubes in buildings and structures shall be wrapped with a 2-inch wide strip of rubber fabric or similar, suitable material at each pipe support, bracket, clip, or hanger.

2.2 SUPPORT SPACING

A. Supports for piping with the longitudinal axis in approximately a horizontal position shall be spaced to prevent excessive sag, bending, and shear stresses in the piping, with special consideration given where components such as flanges and valves impose concentrated loads. Pipe support spacing shall not exceed the maximum spans in the tables below. For temperatures other than ambient temperatures, or those listed, and for other piping materials or wall thicknesses, the pipe support spacings shall be modified in accordance with the pipe manufacturer's recommendations. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of all loading effects.

1. Support Spacing for Schedule 40 and Schedule 80 Steel Pipe

Nominal Pipe Diameter (inches)	Maximum Span (feet)
1/2	6
3/4 and 1	8
1 - 1/4 to 2	10
3	12
4	14
6	17
8 and 10	19
12 and 14	23
16 and 18	25
20 and Greater	30

2. Support Spacing for Welded Fabricated Steel Pipe

Maximum Spans for Pipe Supported in Minimum **120 degree** contact saddles (feet)

Nominal Pipe Diameter (inches)	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
12	31	35	39	41	43					
14	32	36	40	42	44					
16	32	36	40	42	44					
18	32	36	40	42	44					
20	32	36	41	43	45					
22	33	37	41	43	45	47				
24	33	37	41	43	45	47				
26	34	38	41	44	46	48				
28	34	38	41	44	47	49				
30	34	38	42	45	48	49				
32	34	39	42	45	48	50				
34	35	39	42	46	48	50				
36	35	39	43	46	49	51	55			
38	35	39	43	46	49	51	55			
40	35	40	43	47	49	52	56			
42	--	40	43	47	50	52	56			
45	--	40	44	47	50	53	57			
48	--	40	44	47	50	53	58	61		

51	--	41	44	48	51	53	58	62		
54	--	41	44	48	51	54	58	62		
57	--	41	44	48	51	54	59	63		
60	--	41	45	48	52	54	59	63	67	70
63	--	41	45	49	52	55	60	64	67	71
66	--	41	45	49	52	55	60	64	68	71
72	--	41	45	49	52	55	61	65	69	72
78	--	41	45	49	53	56	61	66	69	73
84	--	41	46	50	53	56	62	66	70	74
90	--	41	46	50	53	56	62	67	71	74
96	--	42	46	50	54	57	62	67	71	75

3. For steel pipe sizes not presented in this table, the support spacing shall be designed so that the stress on the pipe does not exceed 5,000 psi. Maximum deflection of pipe shall be limited to 1/360th of the span and shall be calculated by using the formula:

$$L = \sqrt{\frac{7500tD}{32t + D}}$$

Where:
- t = Thickness (inches)
- D = Diameter (inches)
- L = Maximum span (feet)

4. Support Spacing for Ductile-Iron Pipe:

Normal Pipe Diameter (inches)	Maximum Span (feet)
All diameters	Two supports per pipe length or 10 feet (one of the 2 supports located at joint)

5. Support Spacing for Copper Tubing:

Normal Pipe Diameter (inches)	Maximum Span (feet)
1/2 to 1 - 1/2	6
2 to 4	10
6 and greater	12

6. Support Spacing for Schedule 80 PVC Pipe:

Normal Pipe Diameter (inches)	Maximum Span at 100 degrees F (feet)
1/2	4
3/4	4.5
1	5
1 - 1/4	5.5
1 - 1/2	5.75
2	6.25
3	7.5

4	8.25
6	10
8	11
10	12.25
12	13.25

7. Support Spacing for Schedule 80 Polypropylene Pipe:

Normal Pipe Diameter (inches)	Maximum Span at 100 degrees F (feet)
1/2	3
3/4	3.5
1	3.75
1 - 1/4	4
1 - 1/2	4.25
2	4.5
3	5.5
4	6
6	7.25
8	8
10	8.75
12	9.5

8. Support Spacing for Fiberglass Reinforced Plastic (FRP) Pipe:

Normal Pipe Diameter (inches)	Maximum Span at 100 degrees F (feet)
2	8.8
3	10
4	11
6	12.7
8	13.4
10	14
12	15.4
14	16.2
16	17.3
16 and Greater	18

2.3 MANUFACTURED SUPPORTS

A. Stock Parts: Where not specifically indicated, designs which are generally accepted as exemplifying good engineering practice and use stock or production parts, shall be utilized wherever possible. Such parts shall be locally available, new, of best commercial quality, designed and rated for the intended purpose.

B. Manufacturers, or Equal
   1. Basic Engineers Inc., Pittsburgh, PA.
   2. Bergen-Paterson Pipesupport Corp., Woburn, MA.

3. Grinnell Corp. (Supply Sales Company), Cranston, RI
4. NPS Products, Inc., Westborough, MA.
5. Power Piping Company, Pittsburgh, PA.

2.4 COATING

A. Galvanizing: Unless otherwise indicated, fabricated pipe supports other than stainless steel or non-ferrous supports shall be blast-cleaned after fabrication and hot-dip galvanized in accordance with ASTM A 123 - Specifications for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

B. Other Coatings: Other than stainless steel or non-ferrous supports, all supports shall receive protective coatings in accordance with the requirements of Section 90 00 – Paintings and Coatings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Pipe supports, seismic restraints, hangers, brackets, anchors, guides, and inserts shall be fabricated and installed in accordance with the manufacturer's printed instructions and ASME B31.1 - Power Piping. Concrete inserts for pipe hangers and supports shall be coordinated with the form work.

B. Appearance: Pipe supports and hangers shall be positioned to produce an orderly, neat piping system. Hanger rods shall be vertical, without offsets. Hangers shall be adjusted to line up groups of pipes at the proper grade for drainage and venting, as close to ceilings or roofs as possible, without interference with other work.

3.2 FABRICATION

A. Quality Control: Pipe hangers, supports, and seismic restraints shall be fabricated and installed by experienced welders and fitters, using the best welding procedures available. Fabricated supports shall be neat in appearance without sharp corners, burrs, and edges.

END OF SECTION

SECTION 40 05 10
MILL PIPING – EXPOSED AND BURIED

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall furnish and install all exposed and buried mill piping (pipe diameter 6 inches and less) as shown and in accordance with Contract Documents. This section applies to all mechanical Work and associated piping systems. Work related specifically to plumbing piping systems shall be performed in accordance with Section 22 11 16 – Domestic Water Piping.

B. All work shall be in strict accordance with the International Plumbing Code, and codes of the State of Utah, City of Riverton, and any other authorities having jurisdiction. The Contractor shall have required certifications and be thoroughly familiar with the local codes. The Contractor shall obtain and pay for all necessary permits.

C. This section outlines requirements the following small (pipe diameter 6 inches and less) mechanical piping and associated accessories:
1. Small steel pipe
2. Solvent welded PVC pipe and Valves
3. CPVC pipe and Valves
4. PVDF pipe

D. The Contractor shall furnish hoses, hose racks and signage where indicated on the Drawings and as indicated herein.

1.2 REFERENCE STANDARDS

A. Commercial Standards

ANSI/ASME B16.3	Malleable Iron Threaded Fittings
ANSI/ASME B16.4	Gray Iron Threaded Fittings,
ASMEB16.5	Pipe Flanges and Flanged Fittings,
ANSI B16.11	Forged Steel Fittings, Socket-Welding and Threaded
ANSI B16.12	Cast-Iron Threaded Drainage Fittings
ANSI/ASME B16.15	Cast Bronze Threaded Fittings, Classes 125 and 250
ANSI B16.21	Nonmetallic Flat Gaskets for Pipe Flanges
ANSI B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASTM A 53	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 74	Specification for Cast Iron Soil Pipe and Fittings
ASTM A 105	Specification for Carbon Steel, Forgings for Piping Applications
ASTM A 106	Specification for Seamless Carbon Steel Pipe for High Temperature Service
ASTM A 312	Specification for Seamless and Welded Austenitic Stainless Steel Pipe
ASTM A 518	Specification for Corrosion-Resistant High-Silicon Iron Castings
ASTM B 43	Specification for Seamless Red Brass Pipe, Standard Sizes
ASTM B 62	Specification for Composition Bronze or Ounce Metal Castings
ASTM B 88	Specifications for Seamless Copper Water Tube
ASTM C 599	Specification for Conical Process Glass Pipe and Fittings.
ASTM D 1785	Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2996	Specification for Filament-Wound Reinforced Thermosetting Resin Pipe
ASTM D 3222	Specification for Unmodified Poly (Vinylidene Fluoride) (PVDF) Molding, Extrusion, and Coating Materials
ASTM D 4101	Specification for Propylene Plastic Injection and Extrusion Materials
ASTM F 441	Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

B. Chlorine Institute Pamphlet 6 Piping Systems for Dry Chlorine

1.3 CONTRACTOR SUBMITTALS

A. For the materials and equipment items supplied under the provisions of this Section, submit copies of the manufacturer's product specifications and performance details according to the requirements of Section 01 33 20 - Contractor Submittals.

B. Product information for all valves shall be submitted in accordance with Section 40 05 51 – Valves, General.

PART 2 - PRODUCTS

2.1 SMALL STEEL PIPE (SYSTEMS 1, 2, 3 AND 6)

A. Unless otherwise indicated, galvanized steel pipe and black steel pipe in sizes 6 inches in diameter and smaller shall conform to the requirements of ASTM A 53 or ASTM A 106, as called out in the piping schedule and shall be Schedule 40 or 80 as indicated. Galvanized steel pipe shall not be cement mortar lined unless otherwise indicated. Fittings for galvanized steel pipe shall be of galvanized malleable iron, with NPT or grooved ends. Black pipe may have welded joints, with standard or extra strong welding fittings, or fittings indicated. Wall thickness of wrought-steel pipe shall comply with ASME B36.10M.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
2. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
3. Steel Welding Fittings: ASME B16.9, wrought steel or ASME B16.11, forged steel.
4. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1. Unions shall be as manufactured by Henry Valve Company; Vogt Valve Co.; or equal.
5. Cast-Iron Flanges and Flanged Fittings: ASME B16.1, Class 125.
6. Joint Compound and Tape: Suitable for natural gas.
7. Steel Flanges and Flanged Fittings: ASME B16.5.
8. Gasket Material: Thickness, material, and type suitable for natural gas.

2.2 COPPER TUBING (SYSTEM 24)

A. Hard Copper Tube and Fittings: ASTM B 88, Type L and ASTM B 88, Type M water tube, drawn temper.

1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.
3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
5. Copper Pressure-Seal-Joint Fittings:
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following: Elkhart Products Corporation; Industrial Division; NIBCO INC.; Viega; Plumbing and Heating Systems.
    b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
    c. NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.
6. Copper Push-on-Joint Fittings:
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) NVent LLC.
    b. Description: Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22; with stainless-steel teeth and EPDM-rubber O-ring seal in each end instead of solder-joint ends.

B. Soft Copper Tube and Fittings: ASTM B 88, Type K and ASTM B 88, Type L water tube, annealed temper.
   1. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
   2. Copper Pressure-Seal-Joint Fittings:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following: Elkhart Products Corporation; Industrial Division; NIBCO INC.; Viega; Plumbing and Heating Systems.
      b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
      c. NPS 3 and NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

2.3 CPVC (CHLORINATED POLYVINYL CHLORIDE) PRESSURE PIPE, SOLVENT-WELDED (SYSTEM 17)

A. CPVC system and components shall conform to the requirements of Section 33 05 19 – Pressure Piping Tied Joint Restraint System.

B. Solvent Cements for Joining CPVC Piping and Tubing shall conform to ASTM F 493 and the requirements of Section 33 05 19 – Pressure Piping Tied Joint Restraint System.

C. CPVC Ball Valves shall conform to Section 40 05 63 – Ball Valves.

D. CPVC Ball-Check and Swing-Check Valves shall comply with Section 40 05 65 – Valves for Pump Control and Check Service.

2.4 HOSE BIBBS AND HYDRANTS

A. All hose bibbs and hydrants in exposed locations subject to freezing shall be the non-freeze type. Hose bibbs connected to a non-potable water supply shall be provided with plastic or stainless-steel warning signs "DO NOT DRINK," in clearly legible letters, and permanently attached at the hose bibb. Hose bibbs shall be provided with vacuum breakers as furnished by Crane Co., American Standard, or equal.

B. Manufacturers, or Equal:

Dwg. Callout	Fixture Type	Description
HB-1	Non-freeze Post-type	Exposed bronze hydrant, post-type, depth of bury to suit local conditions; minimum 4 feet. 1. Woodward Mfg. Co., Model Iowa Y1
HB-2	Non-freeze wall-type	Heavy duty bronze hydrant with nickel-bronze face, hinged cover, recessed box, and key. Length to suit wall. 1. Josam Mfg. Co., Series 71000 2. Jay R. Smith Mfg. Co., Fig. 5510/5511 3. Zurn Industries, Inc., Fig. Z-1300

HB-3	Hose valves	Heavy duty bronze hydrant, with composition disc, handwheel, cap and chain. Sizes 1 1/2-inch and 2 1/2 inch: 1. Fire-End and Croker Corp, Model 180 2. James Jones (Watts Regulator Co., Nos. J-383 and J-344, respectively Size 1-inch, without cap and chain: 1. Apollo (Conbraco Industries, Inc.), Model 70-805 2. Fire-End and Croker Corp, Model 180 Size 3/4-inch, without cap and chain: 1. Apollo (Conbraco Industries, Inc.) Model 70-804, or 78-104 2. Chicago Faucet No.7T 3. Ford Meter Box Co., Model B8H-233HB2 4. Woodford Manufacturing Co., Model Y24 or 24P
HB-4	Wall box type	Recessed, with nickel-bronze box, hinged cover, and key. 1. Josam Mfg. Co., Series 71020 2. Jay R. Smith Mfg. Co., Series 5710 3. Zurn Industries, Inc., Fig. Z-1345

2.5 SHOCK ABSORBERS

A. Install shock absorbers in accordance with Section 22 11 16 – Domestic Water Piping .

2.6 ACCESS DOORS AND COVERS

A. Install access doors and covers in accordance with Section 22 11 16 – Domestic Water Piping.

2.7 WALL-MOUNTED HOSE RACKS

A. The Contractor shall provide wall-mounted hose racks at locations indicated. Racks shall be all welded steel construction, of minimum 8-gage sheet steel, hot-dip galvanized after fabrication, and shall have a capacity to hold 100 feet of 3/4-inch or 1-1/2-inch hose. Where racks are located in the open, they shall be supported from two 2- by 2- by 1/4-inch galvanized steel angle posts set in a concrete base or as indicated.

2.8 HOSES AND NOZZLES

A. The Contractor shall furnish the following lengths of hose:
   1. 1 - 50 ft lengths of 3/4-inch diameter hose
   2. 1 - 75 ft lengths of 1-inch diameter hose

B. Each length of hose shall be provided with male and female connectors and nozzle. Hoses shall be seamless extruded rubber with dacron cotton exterior designed for a working pressure of at least 200 psi.

C. Nozzles shall be capable of complete shut-off and shall produce a solid straight stream and up to a 90-degree conical fog. Nozzle material shall be polished brass. Nozzles shall have rubber bumpers.

D. Nozzle Manufacturers, or Equal:
   1. W.D. Allen Mfg. Co., Illinois
   2. Fire-End and Crocker Corp., New York
   3. Halprin Supply Co., Illinois
   4. Western Fire Equipment Co., California

2.9 GASKETS AND BOLTS

A. Except as otherwise indicated, gaskets for flanged joints shall be in accordance with the requirements of Section 40 05 00 - Piping, General.

B. Except as otherwise indicated, bolts shall conform to the requirements of Section 05 50 00 – Metal Fabrications.

2.10 INSULATING CONNECTIONS

A. Insulating bushings, unions, couplings or flanges, as appropriate, shall be used for joining pipes of dissimilar metals, and for piping systems where corrosion control and cathodic protection are involved, in accordance with the requirements of Section 22 00 00 –Plumbing Piping and Fittings.

2.11 PIPE INSULATION

A. Hot and cold liquid piping shall be installed in accordance with Section 22 11 16 – Domestic Water Piping.

2.12 PIPE SUPPORTS

A. Pipe Supports, hangers, anchors, seismic restraints, and guides shall be in accordance with the requirements of Section 40 05 07 - Pipe Supports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Small Steel Pipe: Buried galvanized or black steel pipe shall be coated as specified in Section 09 90 00 – Painting and Coating or provided with an extruded high density polyethylene coating with minimum thickness of 35 mils.

B. Plastic Pipe: PVC, CPVC, and FRP pipe joints shall be solvent-welded in accordance with the manufacturer's instructions. Expansion joints or pipe bends shall be provided to absorb pipe

expansion over a temperature range of 100 degrees F, unless otherwise indicated. Care shall be taken to provide sufficient supports, anchors, and guides, to avoid stress on the piping. Obtain the services of the pipe manufacturer, to instruct the pipe fitters in the correct way of making solvent welded and threaded joints. Only clean, fresh primer and solvent shall be used at all times at the recommended temperatures.

C. Drain Traps: Drain traps shall be installed at low points in air and gas lines or elsewhere where indicated. Liquid outlets shall be piped to the nearest floor drain or open sump.

D. Couplings: Pipe couplings shall be installed in strict accordance with the manufacturer's printed recommendations, using the correct style coupling and gasket for any given application.

E. Gaskets for Flanged Joints: Gaskets shall be in accordance with the requirements of Section 40 05 00 - Piping, General.

F. Insulating Connections: All insulating connections shall be installed in accordance with manufacturer's printed instructions. Care shall be exercised to prevent damage to insulating fittings, while making up the joints.

3.2 CONTINUITY BONDS

A. Where required by the Contract Documents, all metallic pipe joints, except field-welded joints and insulating joints, shall be continuity bonded in accordance with the requirements of Section 40 05 00 - Piping, General.

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SECTION 40 05 50
MISCELLANEOUS VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide miscellaneous valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 05 51 – Valves, General, apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 40 05 51.

PART 2 - PRODUCTS

2.1 AIR-VACUUM AND AIR-RELEASE VALVES

A. Air and Vacuum Valves: Air and vacuum valves shall be capable of venting large quantities of air while pipelines are being filled and allowing air to re-enter while pipelines are being drained. They shall be of the size indicated, with flanged or screwed ends to match piping. Bodies shall be of high-strength cast iron. The float, seat, and moving parts shall be constructed of Type 316 stainless steel. Seat washers and gaskets shall be of a material insuring water tightness with a minimum of maintenance. Valves shall be designed for minimum 150 psi water-working pressure, unless otherwise indicated.

B. Air-Release Valves: Air-release valves shall vent accumulating air while system is in service under pressure and be of the size indicated. Valves shall meet the same general requirements as indicated for air and vacuum valves except that the vacuum feature will not be required. Valves shall be designed for a minimum water-working pressure of 150 psi, unless otherwise indicated.

C. Combination Air Valves: Combination air valves shall combine the characteristics of air and vacuum valves and air release valves by exhausting accumulated air in systems under pressure and releasing or re-admitting large quantities of air while a system is being filled or drained, respectively. Valves shall have the same general requirements as indicated for air and vacuum valves.

D. Manufacturers
   1. APCO (Valve and Primer Corporation)
   2. Crispin - Multiplex Manufacturing Company
   3. GA Industries
   4. Val-Matic (Valve and Manufacturing Corporation)
   5. Engineer approved equal.

2.2 AIR AND VACUUM VALVES FOR VERTICAL TURBINE AND SUBMERSIBLE TURBINE PUMPS

A. An air and vacuum valve for the vertical turbine pump shall be installed on the pump discharge pipe indicated. The valve shall vent large quantities of air out through the orifice when pump starts, close tight when liquid enters, and permit large quantities of air to re-enter through orifice when pump stops, to prevent vacuum forming in the pump column. They shall be of the size indicated, with flanged or screwed ends to match piping. Bodies shall be of high-strength cast iron. The float, seat, and moving parts shall be constructed of Type 316 stainless steel. Seat washers and gaskets shall be of a material insuring water tightness with a minimum of maintenance. The discharge orifice shall be fitted with a double-acting throttling device to regulate and restrict air venting, which shall establish a pressure loading on the rising column of water and eliminate damaging shock to the pump, controls, and valves during pump start. On pump stop, a double-acting throttling device shall automatically open, allowing full line unrestricted air re-entry to prevent any vacuum from forming in the pump column. The valve shall be designed for minimum 150 psig water-working pressure.

B. Manufacturer
1. APCO (Valve and Primer Corporation)
2. Val-Matic (Valve and Manufacturing Corporation)
3. Engineer approved equal.

2.3 VACUUM RELIEF/AIR INLET VALVE FOR SURGE TANK

A. A vacuum relief/air inlet valve shall be installed on the surge tank. The vacuum relief/air inlet valve shall be normally closed, capable of admitting large quantities of air into the system immediately should the system pressure become negative and preventing a vacuum from forming during draining, pipeline rupture, or water column separation. The valve shall be of the size indicated, with flanged ends to match piping connections. Bodies shall be of high-strength cast iron with a steel hood. The float, seat, spring, and moving parts shall be constructed of Type 316 stainless steel. The internal valve-plug and seat shall be heavy cast brass. The plug shall be normally closed by means of a stainless steel spring and shall open when a vacuum/pressure differential exceeds 0.25 psig or less. Seat seal shall be of Buna-N providing a drip-tight seal. Valves shall be designed for minimum 150 psig water-working pressure, unless otherwise indicated.

B. Manufacturers
1. APCO (Valve and Primer Corporation)
2. Val-Matic (Valve and Manufacturing Corporation)
3. Engineer approved equal.

2.4 BACKFLOW PREVENTER VALVES

A. General: Backflow preventers shall work on the reduced pressure principle. They shall consist of 2 spring-loaded check valves, automatic differential pressure relief valve, drain valves, and shut-off valves. The body material shall be bronze or cast iron for a working pressure of not less than 150 psi, with bronze or stainless steel trim. Drain lines with air gaps shall be provided. The backflow preventer valves shall be in accordance with AWWA C511 standard.

B. The number and sizes of backflow preventors required are given on the Contract Drawing P&IDs.

C. Manufacturers
   1. Cla-Val Company
   2. Febco (CMB Industries)
   3. Hersey Products
   4. Watts, ACV
   5. Wilkins Regulator Division (Zurn Industries)
   6. Engineer approved equal.

2.5 CORPORATION STOPS

A. Unless otherwise indicated, corporation stops shall be made of solid brass for key operation, with screwed ends with corporation thread or iron pipe thread, as required. Note that corporation stops on special chemical diffuser ports shall be 316 stainless steel – unless indicated otherwise.

B. Manufacturer
   1. Ford Meter Box Company, Inc.
   2. James Jones Company (Watts, ACV)
   3. Mueller Company
   4. Engineer approved equal.

2.6 MUD VALVES

A. Mud valves shall be flanged, non-rising stem type, with threaded stem, seat ring, and gate ring of bronze. Valves shall be provided with coupling nut, extension stem, stem guides, and operating stand, and wheel or wrench nut as indicated. Mud valve shall be installed with valve seats level.

B. Manufacturers
   1. Clow
   2. Mueller
   3. Engineer approved equal.

2.7 PRESSURE RELIEF VALVES FOR TANKS

A. Materials:
   1. Cover: Ductile iron, bronze, or Stainless Steel.
   2. Body and strainer: Ductile iron or Stainless Steel.
   3. Seal ring: Neoprene rubber

B. Size
   1. Valve Body: Minimum 4-inch diameter, length sufficient to penetrate the granular material under the slab by at least 2 inches.

C. Manufacturers
   1. Neenah Foundry; R-5000, Type C
   2. Penn-Troy Manufacturing, Inc.; Troy Valve

3. Trumbull Industries, Inc.
4. Engineer approved equal.

2.8 SOLENOID VALVES

A. Solenoid valves shall be of the size, type, and class indicated and shall be designed for not less than 150 psi water-working pressure. Valves for water, air, or gas service shall have brass or bronze body with screwed ends, stainless steel trim and spring, Teflon or other resilient seals with material best suited for the temperature and fluid handled. Unless otherwise indicated, for chemicals and corrosive fluids, solenoid valves with PVC, polyvinylidene fluoride (PVDF), or Teflon (PTFE) materials of construction, suitable for the specific application shall be provided. Enclosures shall be NEMA rated in accordance with the area designations of Section 26 00 00 – Electrical General Provisions. Coil ratings shall be for continuous duty. For electrical characteristics see the electrical Drawings or Specifications.

B. Manufacturers
1. For general duty
   a. Automatic Switch Co. (ASCO), Model RED HAT
   b. Skinner Valve (Parker Hannifin Corporation)
   c. Magnatrol Valve Corporation
   d. J. D. Gould Co.
   e. Engineer approved equal.
2. Metallic valves for corrosive fluids
   a. Valcor Engineering Corporation
   b. Engineer approved equal.
3. Plastic valves for corrosive fluids
   a. +GF+ Plastic Systems, Inc.
   b. Spears Mfg. Co.
   c. Engineer approved equal.

2.9 FLANGED PRESSURE RELIEF VALVES, SIZES 1-1/2 INCHES THROUGH 42 INCHES

A. Valve Characteristics: The pressure relief valve shall open when the inlet pressure exceeds a set maximum level. It shall maintain that level and gradually close as the inlet pressure drops below the maximum pressure. The valve shall be a hydraulically operated, adjustable, pilot controlled, diaphragm type globe or angle valve as indicated. All necessary repairs shall be possible without removing the valve from the pipeline.

B. Valve Body: The valve body shall be of cast iron, ASTM A 48 – Gray Iron Castings, or ASTM A 126 – Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with 125 lb or 250 lb flanged ends to ANSI/ASME B 16.1 – Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800, or the body shall be of ductile iron to ASTM A 536 – Ductile Iron Castings, with 150 lb or 300 lb flanged ends to ANSI/ASME B 16.42 - Ductile Iron Pipe Flanges and Flanged Fittings. The valve cover shall be flanged and be of the same material as the body. Contractor is to select the appropriate valve pressure class as listed in the valve schedule and as recommended by the valve manufacturer to provide suitable operating service.

C. Valve Trim: The valve stems, springs, body seat rings, and all bolts, nuts, and washers shall be of Type 302, 303, or 316 stainless steel. The valve stems shall have top and bottom guides.

All rubber parts shall be of Buna-N. The diaphragms shall be of Nylon-reinforced Buna-N, supported firmly between body and valve cover. The valve pistons and piston liners shall be bronze to ASTM B 62- Composition Bronze or Ounce Metal Castings.

D. Valve Controls: The valve shall be furnished with a complete, externally mounted control system, including adjustable speed control needle valves, strainer, and all necessary [copper or stainless steel] connecting tubing and fittings. The controls shall be capable of achieving all the flow and speed adjustment indicated.

E. Features: Where indicated in the Drawings, the relief valves shall be equipped with a limit switch to remotely detect valve position.

F. Factory Tests and Warranty: Valves shall be factory tested with a hydrostatic test and a functional test and a test certificate shall be submitted to the Engineer prior to delivery of valves. Valves shall be warranted for a period of 3 years from the date of shipment to be free of defects in materials and workmanship.

G. Spare Parts: The following spare parts shall be furnished in accordance with Section 40 05 51 (for each valve size):
   1. 1 set of all resilient seals, and discs
   2. 1 diaphragm (for diaphragm valves, only)

H. Manufacturers
   1. Singer Valve, Inc.
   2. Cla-Val Company
   3. Watts, ACV.
   4. Engineer approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Backflow preventers shall be installed in utility water lines where required by applicable codes or regulations, and where indicated on Contract Drawings.

B. Valves shall be installed in accordance with the manufacturer's printed recommendations, and with Section 40 05 51.

C. Backflow preventers, as well as air and vacuum release valves, shall have piped outlets to the nearest acceptable drain, firmly-supported, and installed in such a way as to avoid splashing and wetting of floors and obstruction of traffic.

END OF SECTION

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SECTION 40 05 51
VALVES, GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide valves, actuators, and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 11 00 00 - Equipment General Provisions, apply to the Work of this Section.

C. The provisions of this Section shall apply to all valves and valve actuators except where otherwise indicated. Valves and actuators in particular locations may require a combination of units, sensors, limit switches, and controls indicated in other Sections of the Specifications.

D. Where a valve is to be supported by means other than the piping to which it is attached, the Contractor shall obtain from the valve manufacturer a design for support and foundation that satisfies the criteria in Section 11 00 00. The design, including drawings and calculations sealed by an engineer, shall be submitted with the Shop Drawings. When the design is approved, the support shall be provided.

E. Unit Responsibility: A single manufacturer shall be made responsible for coordination of design, assembly, testing, and furnishing of each valve; however, the Contractor shall be responsible to the Owner for compliance with the requirements of each valve section. Unless indicated otherwise, the responsible manufacturer shall be the manufacturer of the valve.

F. Single Manufacturer: Where two or more valves of the same type and size are required, the valves shall be furnished by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 20 - Contractor Submittals

B. Shop Drawings: Shop Drawings shall contain the following information:
   1. Valve name, size, Cv factor, pressure rating, identification number (if any), and specification section number.
   2. Complete information on valve actuator, including size, manufacturer, model number, limit switches, and mounting.
   3. Cavitation limits for control valves.
   4. Assembly drawings showing part nomenclature, materials, dimensions, weights, and relationships of valve handles, handwheels, position indicators, limit switches, integral control systems, needle valves, and control systems.
   5. Data in accordance with Section 26 20 00 – Low-Voltage Induction Motors for electric motor-actuated valves.
   6. Complete wiring diagrams and control system schematics.
   7. Valve Labeling: A schedule of valves to be furnished with stainless steel tags, indicating in each case the valve location and the proposed wording for the label.

C. Technical Manual: The Technical Manual shall contain the required information for each valve.

D. Spare Parts List: A Spare Parts List shall contain the required information for each valve assembly, where indicated.

E. Factory Test Data: Where indicated, signed, dated, and certified factory test data for each valve requiring certification shall be submitted before shipment of the valve. The data shall also include certification of quality and test results for factory-applied coatings.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. General: Valves and gates shall be new and of current manufacture. Shut-off valves 6-inches and larger shall have actuators with position indicators. Gate valves 18-inches and larger or where chain wheel is required, shall be furnished with spur gear and hand wheel. Buried valves shall be provided with valve boxes and covers containing position indicators and valve extensions. Manual shut-off valves mounted higher than 7-feet above working level shall be provided with chain actuators.

B. Valve Actuators: Unless otherwise indicated, valve actuators shall be in accordance with Section 40 05 52 - Valve and Gate Actuators.

C. Protective Coating: The exterior surfaces of all valves and the wet interior surfaces of ferrous valves of sizes 4-inches and larger shall be coated in accordance with Section 09 90 00 – Painting and Coating. The valve manufacturer shall certify in writing that the required coating has been applied and tested in the manufacturing plant prior to shipment, in accordance with these Specifications. Flange faces of valves shall not be epoxy coated.

D. Valve Labeling: Except when such requirement is waived by the construction manager in writing, a label shall be provided on shut-off valves and control valves except for hose bibbs and chlorine cylinder valves. The label shall be of 1/16-inch plastic or stainless steel, minimum 2-inches by 4-inches in size, as indicated in Section 41 05 02 - Piping Identification Systems, and shall be permanently attached to the valve or on the wall adjacent to the valve as directed by the construction manager.

E. Valve Testing: As a minimum, unless otherwise indicated or recommended by the reference Standards, valves 3-inches in diameter and smaller shall be tested in accordance with manufacturer's standard and 4-inches in diameter and larger shall be factory tested as follows:

1. Hydrostatic Testing: Valve bodies shall be subjected to internal hydrostatic pressure equivalent to twice the water rated pressure of the valve. Metallic valves rating pressures shall be at 100 degrees F and plastic valves shall be 73 degrees, or at higher temperature according to type of material. During the hydrostatic test, there shall be no leakage through the valve body, end joints, or shaft seals, nor shall any part of the valve be permanently deformed. The duration shall be sufficient time to allow visual examination for leakage. Test duration shall be at least 10 minutes.

2. Seat Testing: Valves shall be tested for leaks in the closed position with the pressure differential across the seat equal to the water rated pressure of the valve. The duration of test shall be sufficient time to allow visual examination for leakage. Test duration shall be at least 10 minutes. Leakage past the closed valve shall not exceed 1 fluid ounce per hour per inch diameter for metal seated valves and drop-tight for resilient seated valves.
3. Performance Testing: Valves shall be shop operated from fully closed to fully open position and reverse under no-flow conditions in order to demonstrate the valve assembly operates properly.

F. Certification: Prior to shipment, the Contractor shall submit for valves over 12-inches in size, certified, notarized copies of the hydrostatic factory tests, showing compliance with the applicable standards of AWWA, ANSI, or ASTM.

G. Valve Marking: Valve bodies shall be permanently marked in accordance with MSS SP25 - Standard Marking Systems for Valves, Fittings, Flanges, and Unions.

2.2 MATERIALS

A. General: Materials shall be suitable for the intended application. Materials in contact with potable water shall be listed as compliant with NSF Standard 61. Materials not indicated shall be high-grade standard commercial quality, free from defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended. Unless otherwise indicated, valve and actuator bodies shall conform to the following requirements:
1. Cast Iron: Close-grained gray cast iron, conforming to ASTM A 48 - Gray Iron Castings, Class 30, or to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
2. Ductile Iron: ASTM A 536 - Ductile Iron Castings, or to ASTM A 395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
3. Steel: ASTM A 216 - Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service, or to ASTM A 515 - Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service.
4. Bronze: ASTM B 62 - Composition Bronze or Ounce Metal Castings, and valve stems not subject to dezincification shall conform to ASTM B 584 - Copper Alloy Sand Castings for General Applications.
5. Stainless Steel: Stainless steel valve and operator bodies and trim shall conform to ASTM A 351 - Steel Castings, Austenitic, for High-Temperature Service, Grade CF8M, or shall be Type 316 stainless steel.
6. PVC: Poly Vinyl Chloride materials for valve body, flanges, and cover shall conform to Cell Classification 12454.
7. CPVC: Chlorinated Poly Vinyl Chloride materials for valve body, flanges, and cover shall conform to Cell Classification 23447.
8. NSF Standard 14: Materials shall be listed for use in contact with potable water.

2.3 VALVE CONSTRUCTION

A. Bodies: Valve bodies shall be cast, molded (in the case of plastic valves), forged, or welded of the materials indicated, with smooth interior passages. Wall thicknesses shall be uniform in agreement with the applicable standards for each type of valve, without casting defects, pinholes, or other defects that could weaken the body. Welds on welded bodies shall be done

by certified welders and shall be ground smooth. Valve ends shall be as indicated, and be rated for the maximum temperature and pressure to which the valve will be subjected.

B. Valve End Connections: Unless otherwise indicated, valves 2-1/2 inches diameter and smaller may be provided with threaded end connections. Valves 3-inches and larger shall have flanged end connections.

C. Bonnets: Valve bonnets shall be clamped, screwed, or flanged to the body and shall be of the same material, temperature, and pressure rating as the body. The bonnets shall have provision for the stem seal with the necessary glands, packing nuts, or yokes.

D. Stems: Valve stems shall be of the materials indicated, or, if not indicated, of the best commercial material for the specific service, with adjustable stem packing, O-rings, Chevron V-type packing, or other suitable seal. Bronze valve stems shall conform to ASTM B 584, except that zinc content shall not exceed 16 percent.

E. Stem Guides: Stem guides shall be provided, spaced 10-feet on centers unless the manufacturer can demonstrate by calculation that a different spacing is acceptable. Submerged stem guides shall be 304 stainless steel.

F. Internal Parts: Internal parts and valve trim shall be as indicated for each individual valve. Where not indicated, valve trim shall be of Type 316 stainless steel or other best suited material.

G. Nuts and Bolts: Nuts and bolts on valve flanges and supports shall be in accordance with Section 05 50 00 – Metal Fabrications.

2.4 VALVE ACCESSORIES

A. Valves shall be furnished complete with the accessories required to provide a functional system.

2.5 SPARE PARTS

A. The Contractor shall furnish the required spare parts suitably packaged and labeled with the valve name, location, and identification number. The Contractor shall also furnish the name, address, and telephone number of the nearest distributor for the spare parts of each valve. Spare parts are intended for use by the Owner, after expiration of the correction of defects period.

2.6 MANUFACTURERS

A. Manufacturer's Qualifications: Valve manufacturers shall have a successful record of not less than 5 years in the manufacture of the valves indicated.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. General: Valves, actuating units, stem extensions, valve boxes, and accessories shall be installed in accordance with the manufacturer's written instructions and as indicated. Gates shall be adequately braced to prevent warpage and bending under the intended use. Valves shall be firmly supported to avoid undue stresses on the pipe.

B. Access: Valves shall be installed with easy access for actuation, removal, and maintenance and to avoid interference between valve actuators and structural members, handrails, or other equipment.

C. Valve Accessories: Where combinations of valves, sensors, switches, and controls are indicated, the Contractor shall properly assemble and install such items so that systems are compatible and operating properly. The relationship between interrelated items shall be clearly noted on Shop Drawing submittals.

END OF SECTION

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SECTION 40 05 52
VALVE AND GATE ACTUATORS

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide valve and gate actuators and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to valves and gates except where otherwise indicated in the Contract Documents.

C. Unit Responsibility: The valve or gate manufacturer shall be made responsible for coordination of design, assembly, testing, and installation of actuators on the valves and gates; however, the Contractor shall be responsible to the Owner for compliance of the valves, gates, and actuators with the Contract Documents.

D. Single Manufacturer: Where 2 or more valve or gate actuators of the same type or size are required, the actuators shall be produced by the same manufacturer.

E. The requirements of Section 26 00 00 - Electrical General Provisions apply to the Work of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 20 - Contractor Submittals and Section 40 05 51 - Valves, General.

B. Shop Drawings: Shop Drawing information for actuators shall be submitted together with the valve and gate submittals as a complete package.

C. Calculations: Selection calculations showing dynamic seating and unseating torques versus output torque of actuator.

D. Technical Manuals: The Contractor shall furnish technical manuals for the butterfly valves, butterfly valve manual actuators, and butterfly valve electric motor actuators under one cover and in accordance with the requirements of Section 01 33 20 – Contractor Submittals.

PART 2 - PRODUCTS

2.1 GENERAL

A. Unless otherwise indicated, shut-off and throttling valves and externally actuated valves and gates shall be provided with manual or power actuators. The Contractor shall furnish actuators complete and operable with mounting hardware, motors, gears, controls, wiring, solenoids, handwheels, levers, chains, and extensions, as applicable. Actuators shall have the torque ratings equal to or greater than required for valve seating and dynamic torques,

whichever is greater, and shall be capable of holding the valve in any intermediate position between fully-open and fully-closed without creeping or fluttering. Actuator torque ratings for butterfly valves shall be determined in accordance with AWWA C504 - Rubber-Seated Butterfly Valves. Wires of motor-driven actuators shall be identified by unique numbers.

B. Manufacturers: Where indicated, certain valves and gates may be provided with actuators manufactured by the valve or gate manufacturer. Where actuators are furnished by different manufacturers, the Contractor shall coordinate selection to have the fewest number of manufacturers possible.

C. Materials: Actuators shall be current models of the best commercial quality materials and be liberally-sized for the required torque. Materials shall be suitable for the environment in which the valve or gate is to be installed.

D. Actuator Mounting and Position Indicators: Actuators shall be securely mounted by means of brackets or hardware specially designed and sized for this purpose and be of ample strength. The word "open" shall be cast on each valve or actuator with an arrow indicating the direction to open in the counter-clockwise direction. Gear and power actuators shall be equipped with position indicators. Where possible, manual actuators shall be located between 48- and 60-inches above the floor or the permanent working platform.

E. Standard: Unless otherwise indicated and where applicable, actuators shall be in accordance with AWWA C 540 - Power-Actuating Devices for Valves and Slide Gates.

F. Functionality: Electric, pneumatic, and hydraulic actuators shall be coordinated with the power requirements of Division 26 and instrumentation equipment indicated in Division 40.

G. Fasteners: Fasteners shall be in accordance with Section 05 50 00 - Miscellaneous Metalwork.

H. Protective Coatings: Protective coatings shall be in accordance with Section 09 90 00 – Painting and Coating.

2.2 MANUAL ACTUATORS

A. General: Unless otherwise indicated, valves and gates shall be furnished with manual actuators. Valves in sizes up to and including 4-inches shall have direct acting lever or handwheel actuators of the manufacturer's best standard design. Larger valves and gates shall have gear-assisted manual actuators, with an operating pull of maximum 60 pounds on the rim of the handwheel. Buried and submerged gear-assisted valves, gates, gear-assisted valves for pressures higher than 250 psi, valves 30-inches in diameter and larger, and where so indicated, shall have worm gear actuators, hermetically-sealed water-tight and grease-packed. Other valves 6-inches to 24-inches in diameter may have traveling nut actuators, worm gear actuators, spur or bevel gear actuators, as appropriate for each valve.

B. Buried Valves: Unless otherwise indicated, buried valves shall have extension stems to grade, with square nuts or floor stands, position indicators, and cast-iron or steel pipe extensions with valve boxes, covers, and operating keys. Where so indicated, buried valves shall be in cast-iron, concrete, or similar valve boxes with covers of ample size to allow operation of the valve actuators. Covers of valve boxes shall be permanently labeled as required by the local

Utility Company or the Engineer. Wrench nuts shall comply with AWWA C 500 - Metal - Seated Gate Valves for Water Supply Service.

C. Chain Actuator: Manually-activated valves with the stem located more than 7-feet above the floor or operating level shall be provided with chain drives consisting of sprocket-rim chain wheels, chain guides, and operating chains provided by the valve manufacturer. The wheel and guide shall be of ductile iron, cast iron, or steel, and the chain shall be hot-dip galvanized steel or stainless steel, extending to 5-feet 6-inches above the operating floor level. The valve stem of chain-actuated valves shall be extra strong to allow for the extra weight and chain pull. Hooks shall be provided for chain storage where chains interfere with pedestrian traffic.

D. Floor Stands: Valve actuator floor stands shall be cast iron or fabricated steel pedestals. The centerline of the actuator shall be approximately 42 to 48 inches above the base of the pedestal.

E. Floor Boxes: Hot dip galvanized cast iron or steel floor boxes and covers to fit the slab thickness shall be provided for operating nuts in or below concrete slabs. For operating nuts in the concrete slab, the cover shall be bronze-bushed.

F. Tee Wrenches: Buried valves with floor boxes shall be furnished with 2 operating keys or 1 key per 10 valves, whichever is greater. Tee wrenches sized so that the tee handle will be 2 to 4 feet above ground, shall fit the operating nuts.

G. Manual Worm Gear Actuator: The actuator shall consist of a single or double reduction gear unit contained in a weather-proof cast iron or steel body with cover and minimum 12-inch diameter handwheel. The actuator shall be capable of 90 degree rotation and shall be equipped with travel stops capable of limiting the valve opening and closing. The actuator shall consist of spur or helical gears or worm gearing. The gear ratio shall be self-locking to prevent "back-driving." The spur or helical gears shall be of hardened alloy steel and the worm gear shall be alloy bronze. The worm gear shaft and the handwheel shaft shall be of 17-4 PH or similar stainless steel. Gearing shall be accurately cut with hobbing machines. Ball or roller bearings shall be used throughout. Output shaft end shall be provided with spline to allow adjustable alignment. Actuator output gear changes shall be mechanically possible by simply changing the exposed or helical gearset ratio without further disassembly of the actuator. Gearing shall be designed for a 100 percent overload. The entire gear assembly shall be sealed weatherproof. Manual worm gear actuators shall be Auma GS Series, Limitorque HBC Series, no “Or-Equals”.

H. Traveling-Nut Actuator: The actuator shall consist of a traveling-nut with screw (Scotch yoke) contained in a weatherproof cast iron or steel housing with spur gear and minimum 12-inch diameter handwheel. The screw shall run in 2 end bearings, and the actuator shall be self-locking to maintain the valve position under any flow condition. The screw and gear shall be of hardened alloy steel or stainless steel, and the nut and bushings shall be of alloy bronze. The bearings and gear shall be grease-lubricated by means of nipples. Gearing shall be designed for a 100 percent overload.

I. Schedule for Manual Actuator Types: For a complete schedule of manual actuators required on project valves (4” diameter and larger), see Contract Drawing GM-10 and GM-11.

PART 3 - EXECUTION

3.1 SERVICES OF MANUFACTURER

A. Field Adjustments: Field representatives of manufacturers of valves or gates with pneumatic, hydraulic, or electric actuators shall adjust actuator controls and limit-switches in the field for the required function.

3.2 INSTALLATION

A. Valve and gate actuators and accessories shall be installed in accordance with Section 40 05 51 - Valves, General. Actuators shall be located to be readily accessible for operation and maintenance without obstructing walkways. Actuators shall not be mounted where shock or vibrations will impair their operation, nor shall the support systems be attached to handrails, process piping, or mechanical equipment.

B. Inspection, Startup, and Field Adjustment: An authorized representative of the manufacturer shall visit the Site and witness the following:
   1. Installation of the equipment for not less than two (2) Work Days
   2. Inspection, checking, and adjusting the equipment for not less two (2) Work Days.
   3. Startup and field-testing for proper operation for not less than two (2) Work Days.

C. Instruction of Owner's Personnel: The authorized service representative shall visit the Site for not less than 2 Days to instruct the Owner's personnel in the operation and maintenance of the equipment including step-by-step troubleshooting procedures with necessary test equipment.

END OF SECTION

SECTION 40 05 58
SLUICE GATES

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide hydraulic gates with appurtenances, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all flap gates, slide gates, stop gates, sluice gates, and shear gates, except where otherwise indicated in the Contract Documents.

C. The requirements of Section 11 00 00 – Equipment General Provisions apply to this Section.

D. The requirements of Section 40 05 52 – Valve and Gate Actuators apply to this Section.

E. The Contractor shall assign to a single manufacturer responsibility for furnishing and functional operation of the hydraulic gates including operators and accessories. The designated single manufacturer, however, need not manufacture more than one part of the units but shall coordinate the design, assembly, testing, and installation of the units.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards:

AWWA C501	Cast Iron Sluice Gates
AWWA C 513	Open Channel Fabricated Metal Slide Gates
ASTM A 276	Stainless Steel Bars and Shapes
ASTM B 21	Naval Brass Rod, Bar, and Shapes
ASTM B 584	Copper Alloy Sand Castings for General Applications

1.3 CONTRACTOR SUBMITTALS

A. General: Furnish submittals in accordance with Section 01 33 20 – Submittal Procedures.

B. Shop Drawings: Shop Drawings of all sluice gates.

C. Technical Manuals: Complete technical manuals, including printed instructions for proper maintenance, lubrication, and complete parts list indicating the various parts by name, number, and exploded view where necessary. A list of recommended spare parts for the Owner to store at the facility shall be included

D. Certification: The Contractor shall obtain written certification from the designated single manufacturer, addressed to the Owner, stating that the equipment will efficiently and

thoroughly perform the required functions in accordance with these Contract Documents, and that the designated single manufacturer accepts the Contractor's assignment of responsibility for coordination of gate equipment, including operators, controls, and services required for proper installation and operation. The Contractor shall submit all such certificates to the Engineer.

E. Field Procedures: Instructions for field procedures for installation, adjustments, inspection, and testing shall be provided prior to installation of the gates.

1.4 QUALITY ASSURANCE

A. Equipment Field Testing: The Contractor shall be responsible for the coordination of the tests of each hydraulic gate in the presence of the manufacturer's factory service representative. Excessive leaks shall be corrected and the equipment retested until found satisfactory by the Engineer.

1.5 MANUFACTURER'S SERVICE REPRESENTATIVE

A. Installation and Startup Assistance: Service and testing assistance by the manufacturer's engineering representative for each gate and valve shall be furnished by the Contractor during installation and startup.

B. Instruction of Owner's Personnel: The Contractor shall arrange for the services of a factory service representative to instruct the Owner's personnel in the operation and maintenance of the equipment.

1.6 SPECIAL WARRANTY REQUIREMENT

A. The Contractor shall furnish the manufacturer's written guarantee that the hydraulic gates comply with these specifications. The Contractor shall also furnish the manufacturer's warranties as published in its literature.

PART 2 - PRODUCTS

2.1 GENERAL

A. All equipment provided under this Section shall be new, of current manufacture, and shall be the products of reputable manufacturers specializing in the manufacture of such products and which have had previous experience in such manufacture. The Contractor shall, upon request, furnish the names of not less than 5 successful installations of the manufacturer's equipment of comparable nature to that offered under this contract.

B. All combinations of manufactured equipment which are provided under these Specifications shall be entirely compatible, and the Contractor and the manufacturer shall be responsible for the compatible and successful operation of the various components of the units. All necessary mountings and appurtenances shall be included.

2.2 MATERIALS

A. Materials employed in the manufacture and installation of the hydraulic gates and operators shall be suitable for the intended application. Material not specifically called for shall be high-grade, standard commercial quality, free from defects and imperfection that might affect the serviceability of the product for the purpose for which it is intended.

2.3 HARDWARE

A. Bolts and nuts shall comply with Section 05 50 00 – Metal Fabrication.

2.4 PROTECTIVE COATING

A. Coat ferrous metal in accordance with Section 09 90 00 – Painting and Coating.

2.5 TOOLS AND SPARE PARTS

A. Tools: Furnish special tools necessary for maintenance and repair of the gates. Such tools shall be suitably stored in metal tool boxes and identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.

B. Spare Parts: Furnish the following spare parts in a box as described above for tools, for air or hydraulic actuated gates for each type and size of gate:
   1. One set of directional valves, solenoid or pilot actuated
   2. One set of cylinder actuator seals
   3. One set of filters
   4. One repair kit for the hydraulic pump, containing seals or packing, gaskets, and O-rings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sluice and shear gates shall be installed in strict accordance with the manufacturer's printed recommendations and the requirements herein. Operators shall be located to avoid interference with handrails and structural members.

B. Shortly before setting each gate, a 1/8-inch thick layer of mastic grade polysulfide elastomeric sealant shall be applied to the back of the gate frame. After setting the gate, the nuts shall be turned down on the anchor bolts just far enough to make them snug and to cause the rubber sealant to begin to ooze out, but not far enough to produce any significant stress to the frame. Excess sealant at the edges shall be removed. The sealant shall be allowed to cure for at least 7 days, after which the anchor bolt nuts shall be tightened to their final positions. If gaskets are being used, they shall be installed over the studs in one piece, or dovetailed and cemented with a liquid-type gasket material.

C. Damage to surface coatings incurred during shipment and/or installation shall be repaired to the satisfaction of the Engineer prior to installation.

D. Field modifications of or to gates or gate frames will not be permitted without prior written acceptance from the manufacturer.

END OF SECTION

SECTION 40 05 63
BALL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide ball valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 05 51 - Valves, General apply to this Section.

C. The requirements of Section 40 05 52 - Valve and Gate Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 20 – Submittal Procedures and 40 05 51 - Valves, General.

PART 2 - PRODUCTS

2.1 METAL BALL VALVES (3-INCHES AND SMALLER)

A. General: Unless otherwise indicated, general purpose metal ball valves in sizes up to 4-inches shall have actuators in accordance with Section 40 05 52 - Valve and Gate Actuators.

B. Body: Ball valves up to and including 1.5-inches in size shall have bronze or carbon steel 2 or 3 piece bodies with screwed ends for a pressure rating of not less than 600 psi WOG. Valves 2-inches to 3-inches in size shall have bronze or carbon steel 2 or 3 piece bodies with flanged ends for a pressure rating of ANSI 125 psi or 150 psi unless otherwise indicated.

C. Balls: The balls shall be solid chrome-plated brass or bronze, or stainless steel, with standard port (single reduction) or full port openings.

D. Stems: The valve stems shall be of the blow-out proof design, of bronze, stainless steel, or other acceptable construction, with reinforced teflon seal.

E. Seats: The valve seats shall be of teflon or Buna-N, for bi-directional service and easy replacement.

F. Manufacturers, or Equal
1. Conbraco Industries, Inc. (Apollo)
2. ITT Engineered Valves
3. Neles-Jamesbury, Inc.
4. Watts Regulator
5. Worcester Controls

2.2 PLASTIC BALL VALVES (1.5-INCHES AND SMALLER)

A. General: Plastic ball valves for corrosive fluids shall be made of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), or polyvinylidene fluoride (PVDF), as recommended by the manufacturer for the specific fluid application. Valves shall have manual actuators in accordance with Section 40 05 52 - Valve and Gate Actuators, unless otherwise indicated.

B. Construction: Plastic ball valves shall have true-union ends or flanged ends to mate with ANSI B 16.5, class 150 flanges for easy removal. The balls shall have full size ports and teflon seats. Body seals, union O-ring seals, and stem seals shall be in accordance with the corrosion resistance requirements of [Section 46 33 00]. External (without entering into the wetted area) seat packing adjustment is preferred. Metal reinforced stems to prevent accidental breakage are preferred. Ball valves for sodium hypochlorite solution service shall be drilled through the ball or body per valve manufacturer recommendation to relieve offgas and equalize pressure across the valve. The valves shall be suitable for a maximum working non-shock pressure of 150 psi at 73 degrees F for PVC and CPVC, with decreasing ratings for higher temperatures and other plastics.

C. Manufacturers, or Equal
   1. ASAHI-America
   2. George Fischer, Inc.
   3. NIBCO Inc., (Chemtrol)
   4. Plast-O-Matic Valves, Inc.
   5. Spears Mfg. Co.
   6. Watts Regulator

PART 3 - EXECUTION

3.1 GENERAL

A. Valves shall be installed in accordance with Section 40 05 51 – Valves, General. Care shall be taken that valves in plastic lines are well supported at each end of the valve.

END OF SECTION

SECTION 40 05 64
BUTTERFLY VALVES

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall provide butterfly valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 11 00 00 – Equipment General Provisions apply to this Section.

C. The requirements of Section 40 05 51 – Valves, General apply to this Section.

D. The requirements of Section 40 05 52 – Valve and Gate Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 40 05 51 – Valves, General.

B. Shop Drawings
   1. Complete Shop Drawings of butterfly valves and actuators.
   2. Drawings showing valve port diameter complete with dimensions, part numbers, and materials of construction.
   3. Certification of proof-of-design test from the valve manufacturer.
   4. Certification: The Contractor shall obtain written certification from the butterfly valve manufacturer, addressed to the Owner, stating that the butterfly valves and the valve operators will efficiently and thoroughly perform the required functions in accordance with these Specifications and as shown, and that the manufacturer accepts joint responsibility with the Contractor for coordination of all butterfly valves and valve operators, including motors, drives, controls, and services required for proper installation and operation of the completely assembled and installed units. The Contractor shall submit all such certificates to the construction manager.
   5. Technical Manuals: The Contractor shall furnish technical manuals for the butterfly valves, manual operators, and electric motor valve operators under one cover and in accordance with the requirements of Section 01 33 20 – Submittal Procedures.
   6. Valve Labeling: The Contractor shall submit a schedule of butterfly valves to be labeled indicating in each case the valve location and the proposed wording for the label.
   7. Field Procedures: Written instructions for field procedures for erection, adjustments, inspection, and testing shall be provided prior to delivery of the butterfly valves and valve operators.

1.3 QUALITY ASSURANCE

A. Valves shall be subjected to performance, leakage, and hydrostatic tests in accordance with procedures and acceptance criteria established by AWWA C504.

PART 2 - PRODUCTS

2.1 RUBBER SEATED BUTTERFLY VALVES (AWWA)

A. General: Butterfly valves for water working pressures up to 250 psi shall conform to ANSI/AWWA C504 - Rubber Seated Butterfly Valves, subject to the following requirements. Valves shall be of the size and class indicated. Flanged valves shall have Class 150 or Class 250 flanges conforming to ANSI B16-1.

B. Manual Actuators: Actuators shall conform to Section 40 05 52 - Valve and Gate Actuators and to ANSI/AWWA C540 - Power Actuating Devices for Valves and Sluice Gates, subject to the following requirements. Unless otherwise indicated, all manually-actuated butterfly valves shall be equipped with a handwheel and 2-inch square actuating nut and position indicator. Screw-type (traveling nut) actuators will not be permitted for valves 30 inches in diameter and larger.

C. Worm Gear Actuators: Valves, 30 inches and larger, as well as all submerged and buried valves, shall be equipped with worm-gear actuators, lubricated and sealed to prevent entry of dirt or water into the housing.

D. Manufacturers, or Equal
   1. De Zurik Corporation.
   2. Kennedy Valve.
   3. Mueller

2.2 HIGH PERFORMANCE BUTTERFLY VALVES

A. General: High-performance butterfly valves shall be of the ANSI class 300, lugged design, suitable for working pressures up to 740 psi at temperatures ranging from -20 degrees F to 100 degrees F.

B. Body: The valve body shall be of carbon steel to mate with ANSI class 300 flanges; conforming to ASTM A 216 - Specification for Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service, Type WCB, or ASTM A 515 - Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate-and Higher-Temperature Service, Grade 70.

C. Disc: The disc shall be offset, of Type 316 or 317L Stainless Steel, conforming to ASTM A 351 - Specification for Steel Castings, Austenitic, for High-Temperature Service, or ASTM A 743 - Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, and Nickel-Base Corrosion - Resistant for General Application, respectively.

D. Seat: The valve shall have a soft seat, retained in the body by an Inconel or Type 316 stainless steel ring. The seat material shall be PTFE, TFE, or filled TFE.

E. Shaft: The shaft shall be one-piece construction, Type 316 or 17-4 PH stainless steel.

F. Bearings: The shaft bearings shall be corrosion-resistant and self-lubricating, made of Type 316 stainless steel backed with TFE, or Type 317 stainless steel.

G. Packing: The shaft packing shall be adjustable and field-replaceable of TFE chevron type design or PTFE V-flex style.

H. Actuator: Gear assisted actuators shall be provided for all high performance butterfly valves. The valve actuators for high performance butterfly valves shall be of the traveling nut type or worm-gear type designed for buried service. Actuators shall be designed for the full rating of the valve, and an input torque of 300 foot pounds against the fully adjustable open and closed position stops, as required by AWWA C504. Manual actuators shall allow for positive throttling and locking in any position from open to close.

I. Testing: The valves shall be factory-tested in accordance with Section 40 05 51 - Valves, General.

J. Manufacturers, or Equal
1. De Zurik Corporation.

2.3 BUTTERFLY VALVES FOR AIR SERVICE

A. General: Butterfly valves for air systems shall be specifically designed for this service and meet or exceed the design, strength, performance, and testing standards of AWWA C504. Valves shall be suitable for pressures from vacuum to 125 psi and temperatures from minus 40 degrees F to 250 degrees F.

B. Body: The valve body shall be of cast iron conforming to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, Class B, with either wafer, lug, or flanged design as indicated, drilled to ANSI B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800, Class 125.

C. Disc: The disc shall be of ductile iron conforming to ASTM A 536 - Ductile Iron Castings, or cast iron conforming to ASTM A 48 - Gray Iron Castings, or ASTM A 126 with an edge of monel, Type 316 stainless steel, or nickel. The disc shall be designed with the air-profile or other suitable shape. Sprayed or plated disc edges are not acceptable.

D. Seat: The elastomer seat shall be in the body. It shall be field-replaceable without special tools. Except for use with petroleum-base fluids, the seat material shall be Ethylene-Propylene-Diene Monomer (EPDM), or other suitable material, to provide a tight shut-off at the temperatures above.

E. Shaft: The valve shaft shall be of Type 316 or 304 stainless steel with sufficient strength to allow for the increased torque for air service.

F. Bearings: Shaft bearings shall be of the self-lubricating corrosion-resistant sleeve type.

G. Packing: The packing shall be of the adjustable or self-adjustable (O-ring) type, suitable for the temperature and service conditions.

H. Manual Actuators: Unless otherwise indicated, manually-actuated butterfly valves shall be equipped with a handwheel and 2-inch square actuating nut and position indicator. Screw-type (traveling nut) actuators will not be permitted for valves 30-inches and larger.

I. Worm Gear Actuators: Valves 30-inches and larger shall be equipped with worm-gear actuators, lubricated and sealed to prevent entry of dirt or water into the housing.

J. Electric Actuators: Electric actuators shall meet the requirements of AWWA C540 and be in accordance with Section 40 05 52 – Valve and Gate Actuators. Electric actuators in open/close service shall be rated to produce output torque of at least 1.5 times the required valve maximum seating or maximum dynamic torque whichever is greater. For valves in modulating service with dynamic torque exceeding the seating torque, the rated output torque of the actuator shall be twice the dynamic torque required by the valve. Actuator rated torque is defined as pullout torque rated at 10 percent below the rated voltage of the motor. The torque switch shall be field set at no greater than 60 percent and 50 percent of the maximum actuator rated torque for open/close service and modulating service, respectively. After plant startup, the manufacturer shall prepare a certification including a torque curve to demonstrate that the torque requirements have been met.

K. Testing: Valves shall be factory leak tested in accordance with AWWA C504.

L. Manufacturers, No "Or-Equals":
1. DeZURIK Water Controls Corporation
2. Henry Pratt Company
3. Rodney Hunt Company

2.4 PVC BUTTERFLY VALVES (6-INCH DIAMETER AND SMALLER)

A. General: Valves shall be suitable for steady-state water working pressures and steady-state differential pressures up to 150 psi and for water having a pH range from 6 to 10 and temperature range from 33 to 90 degrees F. The Contractor shall be responsible to insure that the selected butterfly valve will fully open and close without any physical interference at all with schedule 80 PVC Van Stone flanges.

B. Body: Butterfly valves shall be all solid thermoplastic Polyvinyl Chloride (PVC) butterfly valves of the lined body design and shall be suitable for bubble tight shut-off service as well as throttling service. The liner and disc shall be the only wetted parts. All non-plastic exterior valve components, including stem and miscellaneous hardware, shall be Type 316 stainless steel.

C. Disc: The disc shall be made of Ethylene-Propylene-Dene Monomer (EPDM) or Polypropylene (PP) material. The chord length of the valve disc shall be less than the internal diameter of the pipe or flange to which it is to be installed.

D. Seat: Seat shall be of EPDM material to provide bubble-tight seating. The seat shall totally encapsulate the body with no need for flange gaskets for installation. The seat shall be field-replaceable without special tools.

E. Stem: Stems shall be made of Type 316 stainless steel. If connecting pins or screws are required for a particular manufacturer's design, then the disc as well as the connecting hardware shall be Type 316 stainless steel.

F. Stem Bushing: The stem busing shall be a non-corrosive, heavy-duty acetal bushing.

G. Stem Seal: The stem seal shall be a double "U" cup seal or O-ring design which is self adjusting and provides positive sealing in both directions, and is suitable for the service conditions.

H. Flange Style: All PVC butterfly valves 8-inch and smaller on suction side of pumps shall be lug-style valves. All other PVC butterfly valves shall be wafer type, unless otherwise specified.

I. Actuators: Actuators shall conform to Section 40 05 52 – Valve and Gate Actuators and to ANSI/AWWA C540 – Power Actuating Devices for Valves and Sluice Gates. Unless otherwise specified, all PVC butterfly valves 6-inch and smaller shall have manual lever operators. Manual lever type actuators shall allow for positive throttling and have at minimum 10 stop positions from open to closed position for positive locking of the valve.

J. Manufacturers, or Equal;
   1. Asahi America
   2. Hayward

2.5 24-INCH & LARGER BUTTERFLY VALVES FOR DISSOLVED OZONE SERVICE. (V-261, V-510,AND V-520)

A. General: A total of three (3) 24-inch nominal diameter and larger special construction butterfly valves for high concentration dissolved ozone service (up to maximum of 2 ppm dissolved ozone and up to 1% (10,000 ppm) by weight of undissolved ozone gas) with working pressure ratings of 25 psig for fresh water service having a pH range from 7 to 9 and temperature range from 38 to 70 degrees F shall conform to AWWA C504 and be as indicated. Valves shall be of the body type, pressure class, end joint, and actuator indicated. These valves shall be Pressure Class 25B, unless noted otherwise in the Contract Drawing valve schedules, with manual handwheel actuators. Maximum velocity through these butterfly valves shall be less than 4 fps. Valves shall be used for isolation service only.

B. Orientation: Valve shafts shall be installed by Contractor in the horizontal position for all three valves.

C. Construction: Materials of construction shall be as noted below and in accordance with AWWA C504, suitable for the service. Seats shall be 360 degree full-circle seats, positively clamped or bonded into the disc or body of the valve. Cartridge-type seats that rely on a high coefficient of friction for retention shall not be acceptable. Valve end flanges shall conform to AWWA C207 requirements for Class B flange connection.

Description	Material Standards
Valve Bodies	Stainless steel ASTM A 276, Type 316, Class A
End flanges	Same material as valve bodies,
Valve shafts	Stainless steel ASTM A 276, Type 316
Valve discs	Same material as valve bodies.
Valve seats	Viton-A by Dupont or equal; Teflon, or Goretex
Seat mating surfaces	Stainless steel, ASTM A 276, Type 316
Clamps and retaining rings	Type 316 retaining rings and cap screws.

Taper Pins	Type 316 with 316 stainless steel jam nuts and washers. (oversize taper pins to meet strength requirements of design)
Valve shaft bearing / bushing assembly	Self lubricating woven teflon with fiberglass backing (fiberglass resin shall be Dow Derakane Vinylester resin resistant to ozone gas, or approved equal) per AWWA C504
Shaft Bearing O-ring	Viton-A or approved equal
Shaft seals	Bronze / 316 SS packing gland with square TFE impregnated Teflon packing or other resilient non-metallic materials, fully resistant to dissolved ozone and ozone gas; (Viton-A by Dupont or equal, Goretex, or Kalrez)
Welded components	Any welded stainless steel components shall be Type 316L (low carbon) material and not Type 316 stainless steel.
Painting and coating	None required on stainless steel components.

D. Shaft Bearing / Bushing O-Ring Seal: Manufacturer shall provide an O-ring seal (or other approved seal mechanism) on the wetted side of the shaft bearing / bushing to protect the shaft bearing and bushing from constant flushing and attack by the fluid.

E. Worm Gear Actuators: Each valve shall be equipped with worm-gear actuators, lubricated and sealed to prevent entry of dirt or water into the housing. Actuators shall conform to the standards given in Section 40 05 52 Valve and Gate Actuators.

F. Electric Actuators: Each valve shall be equipped with an electric actuator which shall meet the requirements of AWWA C540. Electric actuators shall be rated to produce output torque of at least 1.5 times the required valve maximum seating or maximum dynamic torque, whichever is greater. Electric actuators shall have remote push button actuation stations located approximately 30 to 40 feet away from each valve, as shown on the Contract Drawings. Actuators shall have open and close limit switches and shall conform to the standards given in Section 40 05 52 Valve and Gate Actuators.

G. Manufacturers,
1. Rodney Hunt Company; (Streamseal, single off-set series butterfly valves)
2. De Zurik Corporation
3. Henry Pratt Company
4. No “Or-Equal”

PART 3 - EXECUTION

3.1 INSTALLATION

A. Exposed butterfly valves shall be installed with a means of removing the complete valve assembly without dismantling the valve or operator. Installation shall be in accordance with Section 40 05 51 – Valves, General.

END OF SECTION

SECTION 40 05 65
VALVES FOR PUMP CONTROL AND CHECK SERVICE

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide check valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 05 51 – Valves, General apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 40 05 51 – Valves, General.

PART 2 - PRODUCTS

2.1 SWING CHECK VALVES (3-INCHES AND LARGER)

A. General: Swing check valves for water and general service shall be of the outside lever and spring or weight type, in accordance with AWWA C 508 - Swing-Check Valves for Waterworks Service, 2-in. through 24-in. NPS, unless otherwise indicated, with full-opening passages, designed for a water-working pressure of 150 psi. Units shall have a flanged cover piece to provide access to the disc. Where indicated, swing check valves shall be provided with position indicators.

B. Body: The valve body and cover shall be of cast iron conforming to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with flanged ends conforming to ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800, or be mechanical joint ends, as indicated.

C. Disc: The valve disc shall be of cast iron, ductile iron, or bronze conforming to ASTM B 584 - Copper Alloy Sand Castings for General Applications.

D. Seat and Rings: The valve seat and rings shall be of bronze conforming to ASTM B 584 or B 148 - Aluminum-Bronze Castings or of Buna-N.

E. Hinge Pin: The hinge pin shall be of bronze or stainless steel.

F. Dashpot: If required in the contract documents, a bottom-mounted or side-mounted hydraulic dashpot shall be provided to prevent reverse flow and to alleviate water hammer during the closing cycle of the valve. The dashpot shall have 3 stage closing rates: For the 3 stage closing rate, the first stage shall be adjustable from 100 to 50 percent. The second stage shall be adjustable from 50 to 10 percent. The third stage shall be adjustable from 10 to zero percent. Each rate shall be infinitely and independently field adjustable depending on the system requirement. The dashpot shall be a self-contained oil system separate and independent from the pipeline fluid. The oil reservoir for the closing cycle shall be stainless

steel, open to the atmosphere with an air breather cap to allow oil level changes in the reservoir and also to prevent contamination of the oil from any outside source. The oil reservoir for the opening cycle shall be stainless steel, be hermetically sealed to contain pressure (air over oil), and shall be equipped with a 3-inch diameter pressure gauge and pneumatic fill valve. There shall be a provision for disconnecting the each dashpot from the valve for servicing, without removal of the valve.

G. Manufacturers, or Equal
1. APCO (Valve and Primer Corp.)
2. Kennedy Valve
3. Mueller Company
4. Stockham Valves and Fittings
5. Val-Matic
6. Golden Anderson

2.2 TILTED DISC CHECK VALVES (3-INCHES AND LARGER)

A. General: Tilted disc check valves for water and general service shall be provided with drilled flanges in accordance with ANSI B16.42 for Class 150 ductile iron flanges. Ductile iron flanges shall be flat faced. Flanged inspection ports shall be provided upstream and downstream of the valve disc for inspection or use with optional dashpots on 6 in. and larger valves.

B. Body: The valve body and cover shall consist of two sections bolted together as a central diagonal flange inclined at an angle of 55 degrees. The inlet body section shall contain a seat ring positioned and captured by the diagonal flange. The outlet body section shall accept eccentrically located pivot pin trunnions with sealed covers and lubrication grease fittings. The eccentric pivot trunnions shall be located to divide the disc into approximately 1/3 and 2/3 proportions and also allow the seating surface of the disc to rotate away from the seating surface of the seat ring without contact. Clearance shall be provided between the pivot pin and bushing when the disc is seated to prevent binding and to ensure a tight seal. The valve body shall be constructed of ASTM A536 Grade 65-45-12 ductile iron for Class 150 valves.

C. Disc: The valve disc and seat shall have a seating surface finish of 32 micro-inch or better to ensure positive seating at all pressure. The leakage rate shall not exceed one-half of the allowable rate allowed by AWWA Standard C508 or 0.5 oz per hour per inch of valve size

D. Seat and Rings: The disc in sizes up to 10 in. shall be one-piece construction with integral seat and constructed of ASTM B148 Alloy C95400 aluminum bronze. 12 in. and larger discs shall be ASTM A536 Grade 65-45-12 ductile iron. The disc seating ring shall be ASTM B271 Alloy C95500 centrifugally cast aluminum bronze. The mating seat ring located in the body shall be ASTM B271 Alloy C95400 centrifugally cast aluminum bronze.

E. Pivot Pins: The pivot pins shall be ASTM B505 Alloy C95500 aluminum bronze and shall be guided by a bushing constructed of ASTM B505 Alloy C95400 aluminum bronze.

F. Dashpot: If required in the contract documents, 6” and larger valves should be capable of accepting a field installed Bottom Mounted Oil Dashpot.

G. Manufacturers, or Equal
1. APCO (Valve and Primer Corp.)

2. Kennedy Valve
3. Mueller Company
4. Val-Matic

2.3 SWING CHECK VALVES (2-1/2 INCHES AND SMALLER)

A. General: Swing check valves for steam, water, oil, or gas in sizes 2-1/2 inches and smaller shall be suitable for a steam pressure of 150 psi and a cold water pressure of 300 psi. Units shall have screwed ends unless otherwise indicated, and screwed caps.

B. Body: The valve body and cap shall be of bronze conforming to ASTM B 763 - Copper Alloy Sand Castings for Valve Application, or ASTM B 584 with threaded ends conforming to ASME B1.20.1 - Pipe Threads, General Purpose (inch).

C. Disc: Valves for steam service shall have bronze or brass discs conforming to ASTM B 16 - Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines, and for cold water, oil, and gas service replaceable composition discs.

D. Hinge Pin: The hinge pins shall be of bronze or stainless steel.

E. Manufacturers, or Equal
1. Crane Company
2. Milwaukee Valve Company
3. Stockham Valves and Fittings
4. Wm. Powell Company

2.4 INTERNAL SPRING-LOADED CHECK VALVES (GLOBE STYLE – SILENT CHECKS)

A. General: Internal spring-loaded check valves for water pumps (including all three raw water pumps and the backwash pumps on the DVWTP project), compressors, gas, air, and steam shall be of the full-flow internal spring-loaded poppet type. The valves shall be designed for a water-working pressure of not less than 150 psi unless otherwise indicated.

B. Body: The bodies of valves 3-inches and larger shall be of cast iron conforming to ASTM A 126 with 125 lb flanged ends conforming to ASME B 16.1 unless otherwise indicated. Where necessary, there shall be a positive, watertight seal between the removable seat and the valve body. The stem guide shall be integrally cast with the body or screwed into the body.

C. Valves smaller than 3-inches shall have bronze bodies with screwed ends conforming to ASME B 1.201, suitable for a minimum working pressure of 200 psi, and a temperature of 250 degrees F, unless otherwise indicated. The type of bronze shall be suitable for the intended service.

D. Disc and Stem: The disc and stem of all valves in sizes 3-inches and larger shall be of bronze conforming to ASTM B 584 - Copper Alloy Sand Castings for General Applications, or stainless steel. The stem shall have 2 point bearings. The downstream bearing shall have a bronze or other suitable bushing, to provide a smooth operation.

E. Valves smaller than 3-inches shall have discs and retaining rings of Teflon, nylon, or other suitable material, and stems of bronze, brass, or stainless steel, suitable for the intended service.

F. Stem Guide: The stem guide shall be either firmly fixed in the valve body to prevent it from sliding into the adjacent pipe and damaging the pipe lining, or the valve manufacturer shall provide each valve with one matching flange compatible with the adjacent pipe and its lining to prevent damage to the lining. The compatible flange shall be part of the Shop Drawing submittal.

G. Seat**:** Valves for general service at temperatures up to 250 degrees F shall have bubble-tight shut-off with resilient seats of Buna-N, Teflon, or other suitable material. Valves for steam service and temperatures over 250 degrees F shall have metal-to-metal seating of bronze or stainless steel, as recommended by the manufacturer for the specific service condition. Resilient seats shall be firmly attached to the seating ring by compression molding or other acceptable method.

H. Spring: Valves in sizes 3-inches and larger shall have Type 316 stainless steel springs, and valves smaller than 3-inches shall have stainless steel or beryllium copper springs, as suitable for the service. The spring tension of the valves shall be designed for the individual pressure condition of each valve.

I. Manufacturers, or Equal
   1. APCO (Valve and Primer Corp.)
   2. CPV (Combination Pump Valve Company)
   3. Miller Valve Co., Inc.
   4. VAL-MATIC (Valve and Manufacturing Corporation)

2.5 PLASTIC BALL CHECK VALVES

A. General: Plastic ball check valves for corrosive fluids, in sizes up to 4-inches, shall be used for vertical up-flow conditions only, unless the valves are provided with spring actions.

B. Construction: The valve bodies and balls shall be of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polyvinylidene fluoride (PVDF), or polypropylene (PP) construction, as best suited for each individual service condition. They shall have unions with socket connections or flanged ends conforming to ASME B16.5 - Pipe Flanges and Flanged Fittings, class 150. Seals shall have Viton O-rings, and valve design shall minimize possibility of the balls sticking or chattering. The valves shall be suitable for a maximum working non-shock pressure of 150 psi at 73 degrees F.

C. Manufacturers, or Equal
   1. ASAHI-AMERICA
   2. George Fischer, Inc.
   3. NIBCO Inc. (Chemtrol Division)
   4. Spears Mfg. Co. (PVC, CPVC, AND PP only)

2.6 METAL BALL AND LIFT CHECK VALVES

A. General: Metal ball check valves for saturated steam, oil, water, and gas in sizes 1/2- up to 1-inch shall be used for horizontal installation only. Lift check valves for LP gas in sizes 1/4 up to 2-inches shall be used for horizontal installation only.

B. Construction: The ball check valve body and cap shall be bronze ASTM B 584. Ball disc shall be stainless steel construction, as best suited for each individual service condition. The union cap shall provide a tight joint and be easily dismantled when necessary. They shall have screwed connections. The valves shall be suitable for a maximum working non-shock pressure of 150 psi saturated steam or non-shock cold water, oil, and gas rating of 300 psi.

C. The lift check valve body, and cap shall be leaded bronze ASTM B 763. Disc shall be special composition, as best suited for petroleum service condition. The disc shall be secured to the disc by means of a disc retaining nut. To protect against leakage on light oils and gases, the disc shall be sealed into the holder. The union cap shall provide a tight joint, easily dismantled when necessary. They shall have screwed connections. The valves shall be suitable for a maximum working non-shock pressure of 400 psi cold water, oil, gas, LP gases, and volatile fluids.

D. Manufacturers, or Equal
   1. Crane

2.7 PLASTIC SWING OR WYE-CHECK VALVES

A. General: Plastic swing or wye-check valves for corrosive fluids, in sizes up to 8-inches or as available, may be used for horizontal or vertical up-flow conditions.

B. Construction: The valve bodies and discs or piston shall be of PVC, PP, or PVDF construction as best suited for each individual service condition. They shall have flanged ends conforming to ASME B16.5 Class 150, and flanged top access covers and shall shut positively at no-flow conditions. The seats and seals shall be of EPDM, Teflon, or Viton. The PVC valves shall be rated for a maximum non-shock working pressure of 150 psi at 73 degrees F for sizes 3-inches and smaller. For larger sizes and other materials and temperatures the pressure rating may be lower.

C. Manufacturers, or Equal
   1. ASAHI-AMERICA
   2. George Fischer, Inc.
   3. Spears Mfg. Co. (Plastic Swing Check only)

PART 3 - EXECUTION

3.1 GENERAL

A. Valves shall be installed in accordance with provisions of Section 40 05 51 - Valves, General.

END OF SECTION

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SECTION 40 05 69
PRESSURE RELIEF VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide pressure reducing valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 05 51 - Valves, General, apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 20 – Submittal Procedures and 40 05 51 – Valves, General, including a cavitation study from the valve manufacturer.

PART 2 - PRODUCTS

2.1 GENERAL

A. Function: Pressure reducing valves shall reduce an upstream pressure to a pre-set constant lower pressure, regardless of fluctuations in the upstream pressure.

B. Operation: The valves shall be hydraulically-operated, with diaphragm or piston direct action, pilot-controlled, per paragraph 2.2, and shall be of the globe or angle pattern as indicated. Necessary repairs shall be possible without removing the valves from the pipeline. The smaller direct-acting valves with threaded ends per paragraph 2.3, shall be suitable for water or air service and shall be of the globe pattern.

2.2 FLANGED VALVES, SIZES 1-1/2 INCHES THROUGH 42-INCHES

A. Valve Body: The valve body shall be of cast iron to ASTM A 48 - Gray Iron Castings, or ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with 125 lb flanged ends to ANSI/ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800. The valve cover shall be flanged and be the same material as the body.

B. Valve Trim: The valve stems with position indication, springs, body seat rings, and bolts, nuts, and washers shall be of Type 302, 303, or 316 stainless steel. The valve stems shall have top and bottom guides. Rubber parts shall be Buna-N. The diaphragms shall be of Nylon-reinforced Buna-N, supported firmly between body and valve cover. The valve pistons and piston liners shall be bronze to ASTM B 62 - Composition Bronze or Ounce Metal Castings.

C. Valve Controls: The valve shall be provided with a complete, externally mounted control system, including speed control needle valves, strainers, check valve, isolation valves, and necessary copper or stainless steel connecting tubing and fittings. The controls shall be capable of achieving the flow and speed adjustment indicated.

D. Factory Tests and Warranty: Valves shall be factory tested with a hydrostatic test and a functional test and a test certificate shall be submitted to the Engineer prior to delivery of the valve. The valve shall be warranted for a period of 3 years from the date of shipment to be free of defects in materials and workmanship.

E. Operating Conditions: The valves shall be designed to operate under the conditions as specified in the specific equipment specification or as identified in the Contract P&ID drawings.

F. Spare Parts: The following spare parts shall be furnished in accordance with Section 40 05 51 – Valves, General:
   1. One set of all resilient seals and discs
   2. One diaphragm (for diaphragm valves, only)

G. Manufacturers, or equal
   1. Cla-Val Company
   2. GA Industries
   3. OCV Control Valves
   4. Ross Valve Mfg. Co., Inc.
   5. Singer Valve, Inc.
   6. Watts, ACV

2.3 THREADED VALVES, SIZES 1/2 TO 2-1/2 INCHES

A. Valve Body: The valve body shall be bronze to ASTM B 62 or cast steel, with a minimum pressure rating of 300 psi, and with threaded ends. The valve shall be provided with an integral or an attached strainer with access cap or plug and a flanged or threaded valve cover. The valve shall be actuated by a diaphragm or piston.

B. Valve Trim: The valve stems, springs, body seats, and washers shall be of Series 300 stainless steel. The strainers shall be of stainless steel or monel and the diaphragms shall be of reinforced neoprene. The valve pistons and piston liners shall be bronze to ASTM B 62.

C. Operating Conditions: The valves shall be designed to operate under the conditions as specified in the specific Division 11 equipment specification or as identified in the Contract P&ID drawings.

D. Spare Parts: The following spare parts shall be furnished in accordance with Section 40 05 51 – Valves, General:
   1. One complete set of resilient seals and discs
   2. One diaphragm (for diaphragm valves, only)

E. Manufacturers, or equal
   1. Cla-Val Company
   2. Fisher Controls
   3. GA Industries
   4. Watts, ACV
   5. Wilkins Regulator Div. (Zurn Industries)

2.4 PLASTIC VALVES, SIZES 1/4 TO 2 INCHES

A. Plastic pressure reducing valves shall be designed for not less than 150 psi water working pressure and shall be suitable for the fluid service. For chemicals and corrosive fluids, solenoid valves shall be PVC, CPVC, polypropylene (PP), polyvinylidene fluoride (PVDF), or teflon materials of construction as recommended by the manufacturer for the specific application.

B. Characteristics: Valves shall open when the outlet pressure drops below a set minimum value, and maintain the pressure and open wide as flow requirements dictate. Valves shall be spring- or hydraulically-operated, direct acting, adjustable, diaphragm or piston type as indicated.

C. Manufacturers, or equal
   1. Corrosive Fluids
   2. Plast-O-Matic Valves, Inc.
   3. George Fisher

PART 3 - EXECUTION

3.1 INSTALLATION

A. Valves shall be installed in accordance with provisions of Section 40 05 51 – Valves, General.

3.2 SERVICES OF MANUFACTURERS

A. Inspection, Startup, and Field Adjustment: The service representative of the valve manufacturer shall be present at the Site for 1-Day, to assist the Contractor in the installation and adjustment of the valve(s).

B. Instruction of Owner's Personnel: The training representative of the valve manufacturer shall be present at the Site for 1-Day to instruct the personnel in the operation, adjustment, and maintenance of the valve(s).

C. For the purpose of this paragraph, a Day is defined as an 8 hour period, excluding travel time.

END OF SECTION

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SECTION 40 90 10
CONTROL STRATEGIES

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The System Integrator, under contract to the Owner, shall provide all PLC-Based Control System (PBCS) application programming required to implement the control strategies described in this section, the functions shown on the Drawings and I/O schedules complete and operable in accordance with the Contract Documents.

B. The control strategies in this section are intended to describe the general operation of the systems and processes and address systems that are required to be installed or modified as part of this project and to describe the general operation of the systems and processes. The control strategies are not intended to be all-inclusive operational procedures for the operation of the complete facility. The System Integrator shall make refinements, modifications, and additions to these strategies as needed.

C. The requirements in this section include programming all PLC, RTU, SCADA, and all other PBCS interfaces including network and communication devices.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. The requirements of Section 40 91 00 – Process Instrumentation and Control Systems, Section 40 95 10 – PLC-Based Control System Hardware, and Section 40 95 20 – PLC-Based Control System Software apply and are integral part to this Section.

1.3 ACTION SUBMITTALS/ INFORMATIONAL SUBMITTALS

A. The PLC submittal shall be provided in accordance with the requirements specified in Section 40 91 00 - Process Instrumentation and Control Systems.

B. CONTRACTOR must be aware that the system software submittal in Section 40 91 00 - Process Instrumentation and Control Systems, requires a functional design report of the implemented control functions using as a reference the strategies specified in this section.

1.4 FUNCTIONS AND CONTROL MODES

A. The term Plant Control System (PCS) is used as a generic representation of any type of control system, independent of the technology used to control a facility. The control system can be either a DCS or a PLC based system.

B. Functions

1. LOCAL: The term “LOCAL” means “in the field” i.e., at the physical location of the equipment. Local control means at the equipment or control from the MCC starter.

2. REMOTE: The term "REMOTE" means away from the equipment. Remote control means ability to control the equipment at the pump station HMI or from the SCADA system via telemetry.

3. Local Control Panel (LCP): refers to the presence of a field-situated panel, which serves as a control location. LCPs may contain a PLC.

4. Local Display: This function refers to the display of equipment status or process variable at a location in the field, local to the equipment.

5. Local Interlock: This function refers to the presence of field-situated control logic in which the status of other equipment directly effects the operation and control of the equipment being controlled.

6. Control System Alarms and Status: Variable or status data to be alarmed in the Control Room.

7. Local Alarms: Alarms that are announced in the field.

8. Setpoints: Values which are adjustable at the engineer (supervisor) level displays without requiring any software configuration. Some of these values may be adjustable by the operator from the display station depending on permissions level. Whenever a LOCAL/REMOTE setpoint selection is provided, in LOCAL, the setpoint shall be adjustable from the equipment. In REMOTE, the setpoint shall be adjustable from a REMOTE setpoint input. Final setpoint values shall be determined at commissioning.

C. Control Modes

1. Local Manual Control Mode: This mode enables manual control near the equipment. The equipment is then manually controlled (e.g., START, STOP, OPEN-STOP-CLOSE, etc.) by a local selector switch station by switching it to "HAND" or "OFF", or "OPEN-STOP-CLOSE". The control logic and setpoints in the plant control system PLC are bypassed and do not affect the operation of the equipment. All the controls from the HMI are disabled.

2. Local Automatic Control Mode: This mode enables automatic control that is provided and performed external to the main PLC. In some cases, the equipment in the plant is pre-packaged with a Local Control Panel complete with its own automation logic.

3. Remote Manual Control Mode: This mode allows control from the HMI. To enable Remote Manual mode, the operator switches the field LOCAL/REMOTE switch (LOR) to REMOTE and the AUTO/MANUAL" switch at the HMI to "MANUAL". In this mode the operator can "START", "STOP", "OPEN", CLOSE" etc. the equipment, or manually change the control output to the equipment. Consequently, in this mode the automatic control logic and setpoints in the PICS are overridden.

4. Remote Automatic Control Mode or SCADA Mode: This mode allows control of the equipment from the automatic PLC logic. The operator at the control room switches the "AUTO/MANUAL" switch at the HMI to "AUTO" position to enable PCIS automatic operation. In this mode the equipment is controlled automatically by the control logic

and setpoints residing in the PLC. Personnel with the elevated security credentials can change operational parameters through the HMI by entering new setpoints. The PLC shall monitor equipment local control mode status i.e., (LOCAL/ REMOTE) field switches, and disable Remote Auto mode when any affected equipment LOR is changed to LOCAL.

D. General Control and Mode Switch Terms

1. "LOCAL-OFF-REMOTE" Switch: The LOR switch is located at the equipment in the field or at the MCC.

   a. LOCAL Position: In this position equipment automation and control from the control panel/PLC are bypassed. The control is being delegated away from the PLC. Control from the HMI is also disabled.

   b. OFF Position: In this position all equipment control functions are off and disabled.

   c. REMOTE Position: In this position equipment automation and control are available from the control panel/PLC. An AUTO-MANUAL and a START-OFF-STOP switch (or OPEN-OFF-CLOSE) shall be provided at the operator HMI workstation from which remote manual control is performed.

2. "HAND-OFF-AUTO" Switch: This switch is located usually at the LCP. Control through this switch is performed from the LCP only if the LOCAL-OFF-REMOTE switch in the field or at the MCC is in LOCAL position as discussed above. All the control functions are performed locally and external to the PLC.

   a. HAND Position: in this position the equipment is started manually.

   b. OFF Position: The equipment is off.

   c. AUTO: In this position the equipment is automatically controlled locally and external to the PLC by local control hardware.

3. HMI Switches:

   a. For equipment that is controllable from the PLC in either a MANUAL or AUTOMATIC mode, the operator shall be provided with a software "AUTO-MANUAL" selector switch at the operator HMI workstation. This switch is functional only when LOCAL-OFF-REMOTE switch in the field is in REMOTE position. The following are the AUTO- MANUAL functions:

      1) AUTO – In this position the operator delegates and enables the automation and control functions of the equipment to be performed at the PLC/control panel in the field. The operator is unable to manually control the equipment from the HMI.

      2) MANUAL – In this position the operator is able to override the control functions in the PLC and remotely control the field equipment manually from the HMI.

b. A second software switch such as “START-OFF-STOP” or OPEN-STOP-CLOSE”, etc. or as required by the application, shall be provided in the HMI to control the equipment in the field manually from the HMI. Variations of these types of control switches shall be provided for the equipment based on its control application. These switches shall be functional only when the above “AUTO-MANUAL” switch is in “MANUAL” mode.

1.5 CONTROL STRATEGY CONTENTS

A. Control Strategy General Description: The control strategy general description provides a narrative of the process, its related equipment, as well as the function, the philosophy and methodology of the process control. It provides guidelines for programming the control functions. The general description together with detailed functional description and other section of the strategy comprise the design criteria of the process control.

B. Common Functions

1. The following list of Common Control Features shall be implemented on all equipment and as stated in the individual control strategies listed within these specifications.

a. The “Soft I/O” signals described in this document are provided for the CONTRACTOR’S convenience and represent the minimum signals to be derived for the monitoring and control of the equipment. The Contractor shall provide all necessary additional software-derived signals to meet the control strategies at no additional cost to the OWNER.

b. Analog instrumentation failure feature:

1) Out of Range Alarm: All analog inputs shall have a unique instrument failure alarm when the input is below 0 percent or above 100%. This alarm shall be displayed on the HMI as an Out-of-Range alarm.

2) If an analog signal is used to control the operation of the equipment from the PLC, the equipment shall remain running at its last valid setpoint until the analog instrumentation is stable for a tunable time setting.

c. Unless otherwise stated or shown, all discrete outputs shall be maintained outputs. For START/STOP PLC functions, the PLC shall issue a maintained START command until a FAIL state is detected or when a STOP command is issued. When a momentary command is required, the PLC shall issue the command for 2 seconds, and then remove the signal.

d. Pump Control and Status Discrepancies Programming:

1) In general, for equipment that the PLC is allowed to control, the PLC shall provide a FAIL alarm if the equipment fails to comply with a PLC command signal (START, STOP, OPEN, CLOSE) that has been present for more than a tunable time period. In this event, the command shall be removed after the expiration of the tunable time period.

2) A discrepancy/fail alarm shall be generated for any pump or final control element if a discrepancy exists between a system or operator command and the device status. For example, the system commands to start ("CALL") and the pump fails to start ("RUN" status report back) within a programmable time delay, then a discrepancy ("FAIL") alarm shall be generated.

3) Likewise, involuntary change in the device's status shall also generate an alarm. For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.

4) A "FAIL" alarm shall not be generated even if the pump is intentionally started or stopped by an operator switching the HMI control switch to "START" or "OFF" position. However, if the operator turns the switch to "START" position and the pump has not started, a failure alarm shall be announced at the Reuse Building OIT and the plant HMI. Furthermore, if the operator turns off a pump and the pump has not stopped, an alarm shall also be announced. All fail alarms shall be delayed by an adjustable time delay ranging from 0-90 seconds. If a process requires a longer delay time, the System Supplier shall request Engineer approval.

e. Wherever 2 or more pieces of equipment are provided for the same functions, for example secondary reuse pumps, the SCADA system shall alternate the equipment after each use.

f. Where alarms are specified in the control strategy descriptions, alarms shall be initiated from the applicable inputs. If discrete inputs are not available, the specified alarms shall be initiated from the applicable analog input; alarm setpoints shall be operator adjustable.

g. Additional common control and monitoring functions are provided in the "EXECUTION" part of Section 40 95 20 – PLC-Based Control System Software.

h. Historical Data – All analog values shall be collected and trended.

i. Controller Setpoint Handling – Operator entered setpoints shall be constrained to match PLC programmed setpoint ranges. If a value lower than the setpoint range is entered, the PLC program defaults to the lowest allowable value. If a value higher than the setpoint range is entered, the PLC program defaults to the highest allowable value. The PLC shall prohibit entry of setpoints beyond the operational range of a system or process. If a PLC reboot occurs, the setpoints shall be automatically restored with the last entries.

1.6 QUALITY ASSURANCE

A. The control strategies shall be tested as part of the factory and field acceptance tests and in accordance with the requirements specified in Section 40 91 00 – Process Instrumentation and Control Systems.

PART 2 -- PRODUCTS – NONE

PART 3 -- EXECUTION

3.1 70-CS-1 – SECONDARY REUSE PUMP STATION

A. Background - The secondary reuse pump station has a wet well is equipped with three effluent return pumps and four reuse pumps. Effluent water from the disk filters flows into the wet well over a weir. This control strategy describes the intended operation of the reuse pumps. The reuse pumps consist of three identically sized 200 HP pumps and one smaller 50 HP jockey pump. The larger pumps will operate for most of the irrigation season, with two pumps on duty (Lead/Lag) and one in standby (2+1). This provides for 50% pumping redundancy at peak flow. The jockey pump will operate during times when irrigation demands are much lower in the early spring and late fall. Using the jockey pump during low demand portions of the season will prevent excessive cycling of the larger pumps, wet well, and filters outside of peak irrigation season. Large reuse pump and jockey pump operations will be mutually exclusive. The system is designed such that when the reuse station is not in use, plant flow will back up and gravity feed to the existing effluent weir.

B. Reference Drawing: I-15

C. Description: The reuse pumps are controlled by variable speed drives (VFDs) and are operated automatically by the PLC to deliver reuse water to the irrigation reservoir. The pumping system is manually enabled by an operator and then controlled automatically by the PLC. Using software PID level controllers, one for large reuse pumps and one for the jockey pump, the PLC will modulate the speed of the pump(s) to maintain a setpoint level in the wet well. If level in the reservoir rises to a high level, the pump(s) will ramp down, turn off, and be automatically disabled. Pumping restart will not be allowed until the reservoir high level returns to normal and the operator manually re-enables the pumping system. A magnetic flow meter is installed in the reuse discharge pipe to allow the control system to monitor and totalize flow to the reservoir. This meter is also used to flow pace the autosampler. Alum is injected upstream of the pump station in the splitter box and chlorine is injected into the pump discharge header. Turbidity is also measured in the filter effluent chamber. Out of spec chlorine or turbidity levels will stop the pumps but will require manual operator intervention to resolve the issue.

D. The secondary reuse pump station includes the following controlled equipment and instrumentation:

1. Secondary Reuse Pumps

a. 70-P-0031 – Pump 1 – max 1616 gpm @ 150 psi

1) TSH-0031 – motor thermal switch

2) PSH-0031 – discharge high pressure switch

3) PI-0031 – discharge pressure gauge

b. 70-P-0032 – Pump 2 – max 1616 gpm @ 150 psi

1) TSH-0032 – motor thermal switch

2) PSH-0032 – discharge high pressure switch

3) PI-0032 – discharge pressure gauge

c. 70-P-0033 – Pump 3 – max 1616 gpm @ 150 psi

1) TSH-0033 – motor thermal switch

2) PSH-0033 – discharge high pressure switch

3) PI-0033 – discharge pressure gauge

d. 70-P-0034 – Jockey - Pump 4 – max 550 gpm @ 130 psi

1) TSH-0034 – motor thermal switch

2) PSH-0034 – discharge high pressure switch

3) PI-0034 – discharge pressure gauge

2. LT-0030 – Wet well level transmitter

3. LSLL-0030 – Wet well low-low level switch

4. PIT-0030 – Secondary reuse header pressure transmitter

5. PI-0030 - Secondary reuse header pressure gauge

6. FIT-0030 – Secondary reuse discharge flow transmitter

E. Local Manual Control: Local Manual mode is intended to be used for commissioning and maintenance only and should be used with extreme caution. The reuse pumps are intended to operate normally in Remote Auto mode.

1. The operator places the individual pump HAND/OFF/REMOTE (HOR) selector switch at the VFD in the HAND position to start the pump and into the OFF position to stop the pump. Operation from SCADA is disabled when the HOR is in HAND or OFF.

2. Speed adjustments are made directly on the VFD Human Interface Module (HIM).

F. Local Automatic Control: None required

G. Remote Manual Control: Remote Manual mode is intended to be used for commissioning and maintenance only and should be used with extreme caution. The reuse pumps are intended to operate normally in Remote Auto mode.

1. The operator places the individual pump HOR selector switch at the VFD in the REMOTE position to enable REMOTE control. When REMOTE control is enabled, the SCADA system receives an IN REMOTE status input from the VFD for indication at the operator workstation and local control from the VFD is disabled.

2. The operator selects REMOTE MANUAL for the pump at the HMI. REMOTE MANUAL mode and pump run command OFF shall be the default mode any time the VFD HOR is moved from OFF to REMOTE.

3. In this mode the operator may START/STOP and control the speed of the pump from the HMI.

4. A MINIMUM speed setpoint shall be provided at the HMI. Default value shall be determined at commissioning and coordinated with the pump and VFD suppliers to match the VFD minimum speed setting. Setpoint shall be configured such that operators cannot enter any value below the default minimum speed at the HMI.

H. Remote Automatic Control: Remote Auto control shall be used for normal operations. The System Integrator shall adjust the control strategy as required by the Engineer to achieve smooth operation of the pump station, without excessive pump cycling. Since the large reuse pumps (200 HP) and the jockey pump (50 HP) are operated under separate scenarios, they shall be enabled independently and never allowed to both be enabled at the same time.

1. Prior to entering Remote Auto mode, the operator shall ensure the following adjustable setpoints are entered at the HMI. Tags for setpoints are shown below using [TAG].[SETPOINT] syntax for explanatory purposes only. System Integrator may choose the same or a similar syntax provided that the tag name clearly defines the setpoint. Default setpoints listed are for initial use only. Values shall be tested and adjusted at commissioning as needed to provide a safe, smoothly operating system:

   Note: System Integrator shall add PID parameter setpoints as needed and provide restricted access to the setpoints on an HMI controller faceplate. Mean Sea Level (msl) in the table below shall be converted to feet above wet well floor at commissioning and adjusted in coordination with pump installation.

Setpoint	Tag	Default	Units
Large Reuse Pump Minimum Speed	SK-0030.MIN	55	%
Large Reuse Pump Discharge Flow Low-Low	FIT-0030.FALL-A	650	gpm
Large Reuse Pump Discharge Flow Low	FIT-0030.FAL-A	700	gpm
Large Reuse Pump Minimum Target	FIT-0030.MIN-A	727	gpm
Large Reuse Pump Target Flow	FIT-0030.BEP-A	1453	gpm
Large Reuse Pump Maximum Flow	FIT-0030.MAX-A	1990	gpm
Large Reuse Pump Discharge Pressure High	PIT-0030.PAH	170	psi
Large Reuse Discharge Pressure High-High	PIT-0030.PAHH	190	psi
Wet Well Level Setpoint	LIC-0030-A.SP	4221.50	ft
Large Reuse Pump Level Controller Deadband	LIC-0030-A.DB	TBD	ft
Wet Well Level Rising – Start Reuse Lead	LIC-0030-A.START	4219.75	msl

Setpoint	Tag	Default	Units
Wet Well Level Falling – Stop Reuse Pump(s)	LIC-0030-A.STOP	4218.00	msl
Jockey Reuse Pump Minimum Speed	SK-0034.MIN	55	%
Jockey Reuse Discharge Flow Low-Low	FIT-0030.FALL-B	90	gpm
Jockey Reuse Discharge Flow Low	FIT-0030.FAL-B	150	gpm
Jockey Reuse Pump Maximum Flow	FIT-0030.MAX-B	608	gpm
Jockey Reuse Discharge Pressure High	PIT-0030.PAH	170	psi
Jockey Reuse Discharge Pressure High-High	PIT-0030.PAHH	190	psi
Jockey Reuse Pump Level Controller Deadband	LIC-0030-B.DB	TBD	ft
Wet Well Level Rising – Start Jockey	LIC-0030-B.START	4219.75	msl
Wet Well Level Falling – Stop Jockey	LIC-0030-B.STOP	4218.00	msl
Wet Well High Level	LIT-0030.LAH	4228.00	msl
Wet Well High Deviation	LIC-0030.DEV	SP+DB	ft
Wet Well Low Level (set above LSLL)	LIT-0030.LAL	4217.00	msl
High Turbidity	AIT-0031.LAH	TBD	ntu
High-High Turbidity	AIT-0031.LAHH	TBD	ntu
Low Chlorine Residual	AIT-0032.LAL	TBD	mg/L
Low-Low Chlorine Residual	AIT-0032.LALL	1	mg/L
High Chlorine Residual	AIT-0032.LAH	TBD	mg/L
High-High Chlorine Residual	AIT-0032.LAHH	TBD	mg/L

2. The operator places the individual pump HOR selector switch at the VFD in the REMOTE position to enable REMOTE control. When REMOTE control is enabled, the SCADA system receives an IN REMOTE status input from the VFD for indication at the operator workstation and local control from the VFD is disabled. Unless a pump is out of service, all pumps shall be placed in Remote Auto mode for proper Remote Auto operation.

3. The operator selects REMOTE AUTO for the pumps at the HMI. If any large pump is placed in remote auto mode, the jockey pump shall be disabled. If the jockey pump is placed in remote auto mode, large pump remote auto mode shall be disabled.

4. Large Reuse Pump Operation - The operator selects pump 1, 2 or 3 as the Lead pump and one of the other two pumps as Lag. The third pump automatically takes the standby position. The System Integrator shall coordinate with the Owner to establish the method used for initial pump position selection; however, the selected algorithm shall keep pump runtimes evenly distributed.

5. Jockey Pump Operation – Single pump. Lead/lag operation not required.

6. The operator manually enables either large reuse pump operation OR jockey pump operation from the HMI. Enabling one disables the other.

7. Rising Wet Well Level Actions

a. The Lead pump shall start when the wet well level rises to the operator adjustable start level setpoint LIC-0030-A.START. For jockey pump operation the jockey pump shall start when the wet well level rises to the operator adjustable start level setpoint LIC-0030-B.START.

b. After Lead pump start, the PLC level controller modulates pump speed to maintain the wet well at the level setpoint LIC-0030-A.SP +/- deadband (LIC-0030-A.DB). Level controller parameters and deadband shall be adjusted at commissioning by the Systems Integrator and shall be accessible from an HMI controller faceplate. The intent of wet well level control is to match the wet well influent and effluent flows; therefore, it is not necessary to maintain a precise level; however, the level shall be maintained within the deadband such that the pumps operate in a safe, efficient range on their curve.

c. For jockey pump operation, the PLC level controller modulates pump speed to maintain the wet well at the level setpoint LIC-0030-B.SP +/- deadband (LIC-0030-B.DB)

d. If the Lead pump is unable to maintain setpoint and the level continues to rise, the program shall check that the Lead pump is operating at or above the Large Reuse Pump Target Flow FIT-0030.BEP-A. If the pump has not yet reached its target flow, the system shall continue to operate on one pump.

e. If the level continues to rise and exceeds the level setpoint plus deadband (LIC-0030.SP + LIC-0030.DB) the Lag pump shall start, regardless of flow.

f. As the Lag pump ramps up to the Large Reuse Pump Minimum Speed setpoint SK-0030-MIN, the Lead pump shall ramp down to the same value and the two pumps shall again be controlled by the level controller, ramp up, and modulate at the matching speeds to maintain the wet well level setpoint. Both pumps shall be controlled by the same level controller.

g. If the jockey pump is unable to maintain setpoint and the level exceeds the setpoint plus deadband (LIC-0030-B.SP + LIC-0030-B.DB), a deviation alarm shall be triggered, and the pump shall continue to run.

8. Falling Wet Well Level Actions

a. If both Lead and Lag pumps are running and the wet well level falls below the setpoint, the program shall compare the actual flow to the Large Reuse Pump Minimum Target flow FIT-0030.MIN-A. If the flow is above minimum, both pumps shall continue to run. If the flow is at or below minimum, the Lag pump shall stop, and the Lead pump will continue to modulate to maintain wet well level.

b. If the wet well level continues to fall and drops below the level setpoint minus deadband (LIC-0030-A.SP - LIC-0030-A.DB), the Lag pump shall stop, regardless of flow, Lead pump will continue to modulate to maintain wet well level.

c. For jockey pump operation, if the wet well level is falling and drops below the level setpoint minus deadband (LIC-0030-B.SP - LIC-0030-B.DB), the Lag pump shall stop.

d. If a high high-level alarm occurs at the irrigation reservoir, all reuse pumps shall stop regardless of wet well level. Restart is only allowed after the alarm clears and is reset by the operator. Flow into the wet well will back up through the system and gravity feed to the existing effluent weir.

9. As a minimum, the HMI will provide historical logging and trending for the following:

   a. All setpoints

   b. All levels, pressures, flows, and analytical values

10. Secondary reuse flow totalization: The HMI shall display totalized reuse flow. This total may be reset from the HMI by an authorized operator. Reuse flow totals for each enabled flow period will be trended and logged to the historical database by the plant SCADA.

11. Rotation of Pumps: PLC will automatically promote the standby pump to duty upon a failure of a lead or lag pump. The failed pump shall be placed in the standby position if it becomes available again.

I. Hardwired Interlocks: Regardless of control mode, the following hardwired interlocks will stop the pump and require a manual RESET at the VFD:

   a. High Winding Temperature – Each pump motor has an internal thermal switch that is wired to the VFD control interface. The VFD shall be configured and programmed by the VFD supplier to provide an alarm and stop the pump on any high motor temperature event.

   b. High Discharge Pressure – A high discharge pressure switch is wired to the VFD control interface to stop the pump on high discharge pressure. The VFD shall be configured and programmed by the VFD supplier to provide alarm and stop the pump on any high discharge pressure event.

2. Software Interlocks:

   a. Wet well low-level alarm LIT-0030.LAL – Stop all reuse pumps. Allow auto restart without operator intervention when level rises back to start level as described in the Remote Auto narrative.

   b. Wet well low-low level alarm LALL-0030 - Stop all reuse pumps. Allow auto restart without operator intervention when level rises back to start level as described in the Remote Auto narrative.

   c. Irrigation reservoir high level LAHH-0050 – Stop all reuse pumps. Allow restart when alarm clears and is reset by the operator.

d. Chlorine alarm AALL or AAHH – Stop all reuse pumps. Allow restart when alarm clears and is reset by the operator.

e. Turbidity alarm AAHH – Stop all reuse pumps. Allow restart when alarm clears and is reset by the operator.

J. Alarms: The following alarms shall be provided:

1. Motor high temperature for all pump motors

2. Pump high discharge pressure for all pumps

3. Pump fail to run for all pumps

4. All alarms listed in the setpoint table above

5. Wet well high deviation alarm LIT-0030.DEV – Occurs if all available reuse pumps or jockey pump are running at 100% speed and wet well level exceeds setpoint plus deadband. Shall be set to occur at a level that is less than LIT-0030.LAH.

3.2 70-CS-2 – EFFLUENT RETURN PUMPS

A. Background - The secondary reuse pump station has a wet well is equipped with three effluent return pumps and four reuse pumps. This control strategy describes the intended operation of the effluent return pumps. The effluent return pumps consist of three 10 HP pumps.

B. Reference Drawing: I-15

C. Description: The effluent return pumps are controlled by variable speed drives (VFDs) and are operated automatically by the PLC to return effluent water to the C-7 Ditch. The pumping system is manually enabled by an operator and then controlled automatically by the PLC in either flow or level mode using a software PID controller. Depending on the selected mode (default mode is flow control), the PLC will modulate the speed of the pumps to maintain either the flow to the C-7 Ditch or the level in the wet well. Level in the wet well is normally controlled by the secondary reuse pumps as described in control strategy 70-CS-1; however, the effluent return pumps shall be switched to level control mode when the reuse pumps are not in use. Regardless of mode, the pumps will stop on low wet well level as described below. A magnetic flow meter is installed in the effluent return discharge pipe to provide flow feedback and allow the control system to monitor and totalize flow to the ditch.

D. The effluent return pump station includes the following controlled equipment and instrumentation:

1. Effluent Return Pumps

a. 70-P-0041 – Pump 1 – max 1085 gpm @ 10 psi

1) TSH-0041 – motor thermal switch

2) PSH-0041 – discharge high pressure switch

3) PI-0041 – discharge pressure gauge

b. 70-P-0042 – Pump 2 – duty point max 1085 gpm @ 10 psi

1) TSH-0042 – motor thermal switch

2) PSH-0042 – discharge high pressure switch

3) PI-0042 – discharge pressure gauge

c. 70-P-0043 – Pump 3 – duty point max 1085 gpm @ 10 psi

1) TSH-0043 – motor thermal switch

2) PSH-0043 – discharge high pressure switch

3) PI-0043 – discharge pressure gauge

2. LT-0030 – Wet well level transmitter

3. LSLL-0030 – Wet well low-low level switch

4. PIT-0040 – Effluent return header pressure transmitter

5. PI-0040 - Effluent return header pressure gauge

6. FIT-0040 – Effluent return discharge flow transmitter

E. Local Manual Control: Local Manual mode is intended to be used for commissioning and maintenance only and should be used with extreme caution. The effluent pumps are intended to operate normally in Remote Auto mode.

1. The operator places the individual pump HAND/OFF/REMOTE (HOR) selector switch at the VFD in the HAND position to start the pump and into the OFF position to stop the pump. Operation from SCADA is disabled when the HOR is in HAND or OFF.

2. Speed adjustments are made directly on the VFD Human Interface Module (HIM) using the momentary push buttons.

F. Local Automatic Control: None required

G. Remote Manual Control: Remote Manual mode is intended to be used for commissioning and maintenance only and should be used with extreme caution. The effluent pumps are intended to operate normally in Remote Auto mode.

1. The operator places the individual pump HOR selector switch at the VFD in the REMOTE position to enable REMOTE control. When REMOTE control is enabled, the SCADA system receives an IN REMOTE status input from the VFD for indication at the operator workstation and local control from the VFD is disabled.

2. The operator selects REMOTE MANUAL for the pump at the HMI. REMOTE MANUAL mode and pump run command OFF shall be the default mode any time the VFD HOR is moved from OFF to REMOTE.

3. In this mode the operator may START/STOP and control the speed of the pump from the HMI.

4. A MINIMUM speed setpoint shall be provided at the HMI. Default value shall be determined at commissioning and coordinated with the pump and VFD suppliers to match the VFD minimum speed setting. Setpoint shall be configured such that operators cannot enter any value below the default minimum speed at the HMI.

H. Remote Automatic Control – Flow Mode: Remote Auto flow control mode shall be used for normal operations. Level control mode shall be used when reuse pumps are not in use.

1. Prior to entering Remote Auto mode, the operator shall ensure the following adjustable setpoints are entered at the HMI. Tags for setpoints shown below using [TAG].[SETPOINT] syntax are for explanatory purposes only. System Integrator may choose the same or a similar syntax provided that the tag name clearly defines the setpoint. Default setpoints listed are for initial use only. Values shall be tested and adjusted at commissioning as needed to provide a safe, smoothly operating system:

   Note: System Integrator shall add PID parameter setpoints as needed and provide restricted access to the setpoints on an HMI controller faceplate. Mean Sea Level (msl) in the table below shall be converted to feet above wet well floor at commissioning and adjusted in coordination with pump installation.

Setpoint	Tag	Default	Units
Effluent Return Pump Minimum Speed	SK-0040.MIN	55	%
Effluent Return Discharge Flow Low-Low	FIT-0040.FALL	TBD	gpm
Effluent Return Discharge Flow Low	FIT-0040.FAL	TBD	gpm
Effluent Return Minimum Target	FIT-0040.MIN	TBD	gpm
Effluent Return Pump Flow Setpoint	FIC-0040.SP	TBD	gpm
Effluent Return Pump Flow Deadband	FIC-0040.DB	TBD	ft
Effluent Return Discharge Pressure High	PIT-0040.PAH	9	psi
Effluent Return Discharge Pressure High-High	PIT-0040.PAHH	10	psi
Wet Well Level Rising – Start Effluent Pump	LIT-0030.START-B	4219.75	msl
Wet Well Level Falling – Stop Effluent Pump(s)	LIT-0030.STOP-B	4218.00	msl
Wet Well Low Level (set above LSLL)	LIT-0030.LAL	4217.00	msl

2. The operator places the individual pump HOR selector switch at the VFD in the REMOTE position to enable REMOTE control. When REMOTE control is enabled, the SCADA system receives an IN REMOTE status input from the VFD for indication at the operator workstation and local control from the VFD is disabled. Unless a pump is out of service, all pumps shall be placed in Remote Auto mode for proper Remote Auto operation.

3. The operator selects REMOTE AUTO for the pumps at the HMI.

4. The operator selects pump 1, 2 or 3 as the Lead pump and one of the other two pumps as Lag. The third pump automatically takes the standby position. The System Integrator shall coordinate with the Owner to establish the method used for initial pump position selection; however, the selected algorithm shall keep pump runtimes evenly distributed.

5. The operator manually enables effluent pump operation from the HMI

6. The Lead pump shall start when the wet well level rises to the operator adjustable start level setpoint LIT-0030.START-B.

7. After Lead pump start, PLC flow controller modulates pump speed to maintain the effluent flow at the flow setpoint FIC-0040.SP +/- deadband (FIC-0040.DB). Flow controller parameters and deadband shall be adjusted at commissioning by the Systems Integrator and shall be accessible from an HMI controller faceplate. To prevent upset of reuse pump level control, flow shall be maintained within the deadband such that the pumps operate in a smooth manner without excessive pump cycling.

8. If flow is below the setpoint minus deadband (FIC-0040.SP - FIC-0040.DB) and the Lead pump reaches 100% speed, the program shall start an operator adjustable timer. If the timer expires, the Lag pump shall start. As the Lag pump ramps up to the Effluent Reuse Pump Minimum Speed setpoint SK-0040-MIN, the Lead pump shall ramp down to the same value and the two pumps shall ramp up and modulate at the matching speeds to maintain the flow setpoint.

9. If flow rises above FIC-0040.SP plus deadband (FIC-0040.SP + FIC-0040.DB) with both pumps running at minimum speed SK-0040.MIN, the lag pump shall stop.

10. If the flow rises above FIC-0040.SP plus deadband with the Lead pump running alone at minimum speed SK-0040.MIN, the Lead pump shall stop and require an operator enable command to re-start. In this scenario the operator should consider raising the flow setpoint prior to re-enabling the system.

11. As a minimum, the HMI will provide historical logging and trending for the following:

    a. All setpoints

    b. All levels, pressures, flows, and analytical values

12. Effluent flow totalization: The HMI shall display totalized reuse flow. This total may be reset from the HMI by an authorized operator. Effluent flow totals for each enabled flow period will be trended and logged to the historical database by the plant SCADA.

13. Rotation of Pumps: PLC will automatically promote the standby pump to duty upon a failure of the duty pump. The failed pump shall be placed in the standby position if it becomes available again.

I. Remote Automatic Control – Level Mode: Remote Auto flow control mode shall be used for normal operations. Level control mode shall be used when reuse pumps are not in use.

1. Prior to entering Remote Auto mode, the operator shall ensure the following adjustable setpoints are entered at the HMI. Tags for setpoints are shown below using [TAG].[SETPOINT] syntax for explanatory purposes only. System Integrator may choose the same or a similar syntax provided that the tag name clearly defines the setpoint. Default setpoints listed are for initial use only. Values shall be tested and adjusted at commissioning as needed to provide a safe, smoothly operating system:

   Note: System Integrator shall add PID parameter setpoints as needed and provide restricted access to the setpoints on an HMI controller faceplate. Mean Sea Level (msl) in the table below shall be converted to feet above wet well floor at commissioning and adjusted in coordination with pump installation. Refer to Flow Mode setpoint table for flow setpoints that also applicable to Level Mode.

Setpoint	Tag	Default	Units
Wet Well Level Rising – Start Effluent Lead	LIC-0040-A.START	4219.75	msl
Wet Well Level Falling – Stop Effluent Pump(s)	LIC-0040-A.STOP	4218.00	msl
Wet Well Level Setpoint	LIC-0040-A.SP	4221.50	ft
Effluent Pump Level Controller Deadband	LIC-0040-A.DB	TBD	ft
Wet Well High Level	LIT-0030.LAH	4228.00	msl
Wet Well High Deviation	LIC-0040.DEV	SP+DB	ft
Wet Well Low Level (set above LSLL)	LIT-0030.LAL	4217.00	msl
Effluent Pump Target Flow	FIT-0040.BEP-A	TBD	gpm

2. The operator places the individual pump HOR selector switch at the VFD in the REMOTE position to enable REMOTE control. When REMOTE control is enabled, the SCADA system receives an IN REMOTE status input from the VFD for indication at the operator workstation and local control from the VFD is disabled. Unless a pump is out of service, all pumps shall be placed in Remote Auto mode for proper Remote Auto operation.

3. The operator selects REMOTE AUTO for the pumps at the HMI.

4. The operator selects pump 1, 2 or 3 as the Lead pump and one of the other two pumps as Lag. The third pump automatically takes the standby position. The System Integrator shall coordinate with the Owner to establish the method used for initial pump position selection; however, the selected algorithm shall keep pump runtimes evenly distributed.

5. The operator manually enables pump operation from the HMI.

6. Rising Wet Well Level Actions

   a. The Lead pump shall start when the wet well level rises to the operator adjustable start level setpoint LIC-0040-A.START.

b. After Lead pump start, the PLC level controller modulates pump speed to maintain the wet well at the level setpoint LIC-0040-A.SP +/- deadband (LIC-0040-A.DB). Level controller parameters and deadband shall be adjusted at commissioning by the Systems Integrator and shall be accessible from an HMI controller faceplate. The intent of wet well level control is to match the wet well influent and effluent flows; therefore, it is not necessary to maintain a precise level; however, the level shall be maintained within the deadband such that the pumps operate in a safe, efficient range on their curve.

c. If the Lead pump is unable to maintain setpoint and the level continues to rise, the program shall check that the Lead pump is operating at or above the Effluent Target Flow FIT-0040.BEP-A. If the pump has not yet reached its target flow, the system shall continue to operate on one pump.

d. If the level continues to rise and exceeds the level setpoint plus deadband (LIC-0040.SP + LIC-0040.DB) the Lag pump shall start, regardless of flow.

e. As the Lag pump ramps up to the Effluent Pump Minimum Speed setpoint SK-0040-MIN, the Lead pump shall ramp down to the same value and the two pumps shall again be controlled by the level controller, ramp up, and modulate at the matching speeds to maintain the wet well level setpoint. Both pumps shall be controlled by the same level controller.

7. Falling Wet Well Level Actions

a. If both Lead and Lag pumps are running and the wet well level falls below the setpoint, the program shall compare the actual flow to the Effluent Pump Minimum Target flow FIT-0040.MIN-A. If the flow is above minimum, both pumps shall continue to run. If the flow is at or below minimum, the Lag pump shall stop, and the Lead pump will continue to modulate to maintain wet well level.

b. If the wet well level continues to fall and drops below the level setpoint minus deadband (LIC-0040-A.SP - LIC-0040-A.DB), the Lag pump shall stop, regardless of flow, Lead pump will continue to modulate to maintain wet well level..

J. Hardwired Interlocks: Regardless of control mode, the following hardwired interlocks will stop the pump and require a manual RESET at the VFD:

a. High Winding Temperature – Each pump has an internal thermal switch that is wired to the VFD control interface. The VFD shall be configured and programmed by the VFD supplier to provide an alarm and stop the pump on any high temperature event.

b. High Discharge Pressure – A high discharge pressure switch is wired to the VFD control interface to stop the pump on high discharge. The VFD shall be configured and programmed by the VFD supplier to provide alarm and stop the pump on any high discharge pressure event.

2. Software Interlocks:

a. Wet well low-level alarm LIT-0030.LAL – Stop all effluent pumps. Allow auto restart without operator intervention when level rises back to start level as described in the Remote Auto narratives.

b. Wet well low-low level alarm LALL-0030 - Stop all effluent pumps. Allow auto restart without operator intervention when level rises back to start level as described in the Remote Auto narratives.

K. Alarms: The following alarms shall be provided:

1. Motor high temperature for all pump motors

2. Pump high discharge pressure for all pumps

3. Pump fail to run for all pumps

4. All alarms listed in the setpoint table above

3.3 70-CS-3 – FILTERS

A. Refer to vendor Specification 46 61 25 Cloth Media Filters and Aqua Aerobic control strategy submittal.

B. Reference Drawings: I-13, I-14

3.4 70-CS-4 – CHLORINE INJECTION AND MONITORING

A. Background – Secondary reuse water is chlorinated by pumping chlorine solution to the Reuse Building where its pressure is boosted by a chlorine booster pump. Chlorine from the plant chlorine feed system is controlled by existing systems; however, chlorine feedback from the reuse discharge shall be used to adjust feed to the booster pump.

B. Reference Drawings: I-15, I-18, GI-04

C. Description: The chlorine booster pump, 70-P-0061, is started from a local control panel (LCP) either in Local Manual, Remote Manual, or Remote Auto mode. Free chlorine level (AI-0032) and sample flow (FI-0032) shall be monitored by a chlorine analyzer in the Reuse Building. The chlorine signal is connected to the Reuse Building PLC panel by Ethernet/IP and shall be displayed on the HMI to allow the operators to make adjustment decisions. When placed in Remote Auto mode, a chlorine controller shall automatically adjust feed from the existing chlorine system based on an operator adjustable setpoint.

D. Local Manual Control: Local Manual mode is intended to be used for commissioning and maintenance only and should be used with caution. The chlorine booster pump is intended to operate normally in Remote Manual or Auto mode.

1. The operator places the pump HAND/OFF/ REMOTE (HOR) selector switch at the LCP in the HAND position to start the pump and into the OFF position to stop the pump. Operation from SCADA is disabled when the HOR is in HAND or OFF.

E. Local Automatic Control: None

F. Remote Manual Control:

1. The operator places the pump HAND/OFF/REMOTE (HOR) selector switch at the LCP in the REMOTE position to enable operation from SCADA. The HMI shall provide remote start and stop buttons that are enabled when the HOR is in REMOTE to allow the operators to control the pump.

2. Pump start shall not be allowed if the existing chlorine system is not providing chlorine solution to the reuse building none of the reuse pumps are running.

G. Remote Auto Control:

1. Prior to entering Remote Auto mode, the operator shall ensure the following adjustable setpoints are entered at the HMI. Tags for setpoints are shown below using [TAG].[SETPOINT] syntax for explanatory purposes only. System Integrator may choose the same or a similar syntax provided that the tag name clearly defines the setpoint. Default setpoints listed are for initial use only. Values shall be tested and adjusted at commissioning as needed to provide a safe, smoothly operating system:

   Note: System Integrator shall add PID parameter setpoints as needed and provide restricted access to the setpoints on an HMI controller faceplate.

2.

Setpoint	Tag	Default	Units
Chlorine Low-Low Level	AI-0032.LALL	.5	ppm
Chlorine Low Level	AI-0032.LAL	.6	ppm
Chlorine Setpoint	AIC-0032.SP	.75	ppm
Chlorine High Level	AI-0032.LAH	.9	ppm
Chlorine High-High Level	AI-0032.LAHH	1	ppm

3. After switching to Remote Auto mode, the program shall determine that the existing chlorine system is providing chlorine solution to the reuse building and at least one reuse pump is running before starting the chlorine booster pump.

4. A chlorine controller shall be provided in the PLC to automatically adjust dosage to the secondary reuse discharge pipe.

5. Based on chlorine feedback from AIT-0032 and an operator adjustable setpoint, AIC-0032.SP, the chlorine controller shall provide a modulating signal to the existing chlorine system over the network.

H. Hardwired Interlocks: Motor overload in the LCP is the only hardwired interlock for the pump.

I. Software Interlocks:

1. Reuse pumps shall be stopped, and alarms raised on either chlorine low-low or high-high alarms after an operator adjustable time delay. Time delay to be coordinated at commissioning with Operations.

J. Alarms: In addition to the setpoint comparison alarms shown above, the following alarms shall be provided:

1. Chlorine booster pump fail (overload)

2. Chlorine sensor alarm

3.5 70-CS-5 – ALUM INJECTION AND MONITORING

A. Background - Alum is pumped to the splitter box and mixed into the filter influent by mixer 70-MX-0010. The mixer is controlled manually by the operators.

B. Reference Drawing: I-11, I-12, I-13, GI-04

C. Description: Alum feed is controlled by the existing plant feed system. The alum mixer, 70-MX-0010, is started from a local control panel (LCP) either in Local Manual or Remote Manual mode. The Operators shall start the mixer when alum is being fed to the splitter box. Turbidity level (AI-0031) and sample flow (FI-0031) shall be monitored by a turbidity analyzer in the Reuse Building. The turbidity signals are connected to the Reuse Building PLC panel by Ethernet/IP and shall be displayed on the HMI to allow the operators to make alum adjustment decisions.

The following setpoints shall be available at the HMI and adjusted prior to alum feed and mixer operation:

D.

Setpoint	Tag	Default	Units
Turbidity High Level	AI-0031.LAH	TBD	ntu
Turbidity High-High Level	AI-0031.LAHH	TBD	ntu

E. Local Manual Control: Local Manual mode is intended to be used for commissioning and maintenance only and should be used with caution. The mixer is intended to operate normally in Remote Manual mode.

1. The operator places the mixer HAND/OFF/REMOTE (HOR) selector switch at the LCP in the HAND position to start the mixer and into the OFF position to stop the mixer. Operation from SCADA is disabled when the HOR is in HAND or OFF.

F. Local Automatic Control: None

G. Remote Manual Control:

1. The operator places the mixer HAND/OFF/ REMOTE (HOR) selector switch at the LCP in the REMOTE position to enable operation from SCADA. The HMI shall provide remote start and stop buttons that are enabled when the HOR is in REMOTE to allow the operators to control the mixer.

H. Remote Auto Control: None

I. Hardwired Interlocks: Motor overload in the LCP is the only hardwired interlock for the mixer.

J. Software Interlocks:

1. Reuse pumps shall be stopped, and an alarm raised on turbidity high-high after an operator adjustable time delay. Time delay to be coordinated at commissioning with Operations.

K. Alarms: In addition to the setpoint comparison alarms shown above, the following alarms shall be provided:

1. Mixer fail (overload)

2. Turbidity sensor alarm

3.6 70-CS-6 – FILTER SUMP PUMPS

A. Background – A vendor packages duplex sump pump system installed in the filter sump provides dewatering for the sump.

B. Reference Drawing: I-14

C. Description: The PCIS performs monitoring only for the sump pump package. The following signals are monitored and/or alarmed for the sump package:

1. Pump Running - Monitor

2. Pump Fail - Alarm

3. Sump High Level - Alarm

4. Sump High-High Level - Alarm

D. Local Manual Control: Operators may control the sump pumps in Hand at the vendor package LCP as needed to dewater the sump.

1. The operator places the mixer HAND/OFF/AUTO) selector switch at the LCP in the HAND position to start either pump and into the OFF position to stop either pump.

E. Local Automatic Control:

1. On rising level, the lead pump starts when the level triggers LSH

2. If level continues to rise the lag pump starts when the level triggers LSHH

3. On falling level, the pump(s) stop when LSL is reached.

F. Remote Manual Control: None

G. Remote Auto Control: None

3.7 70-CS-7 – AUTOSAMPLER

A. Background – A refrigerated autosampler shall be used to sample reuse effluent.

B. Reference Drawing: I-15

C. Description: The PLC shall send an 4-20mA analog output reuse effluent flow signal to the autosampler.

D. Local Manual Control:

E. Local Automatic Control: The autosampler shall automatically sample the effluent water at a frequency determined by an internally calculated flow volume based on reuse effluent flow pacing. Exact configuration to be coordinated with the Engineer and Owner at commissioning. Refer to Specification 43 70 00 Automatic Refrigerated Samplers for autosampler requirements.

F. Remote Manual Control: None

G. Remote Auto Control: None

SECTION 40 91 00
PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

The CONTRACTOR, using a SYSTEMS SUPPLIER, shall provide Process Control and Instrumentation Systems (PCIS) complete and operable, in accordance with the Contract Documents. For this CONTRACT, PCIS is synonymous and interchangeable with supervisory control and data acquisition (SCADA) and distributed control system (DCS), where applicable. The requirements of this Section apply to every component of the PCIS unless indicated otherwise.

A. Responsibilities

1. The CONTRACTOR, using a single prequalified SYSTEM SUPPLIER, and qualified electrical and mechanical installers, shall be responsible to the OWNER for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices.

2. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the SYSTEM SUPPLIER will be responsible to the CONTRACTOR for the integration of the PCIS with existing devices and devices provided under this and other Divisions with the objective of providing a completely integrated control system free of signal incompatibilities.

3. The CONTRACTOR shall request the OWNER to demonstrate that all existing equipment that is to be reused or interfaced with in this project works properly for the intended function. In the event the existing equipment does not work, the issue should be brought up in the preconstruction/ pre-submittal meeting(s).

4. As a minimum, the implementation of the PCIS by the SYSTEM SUPPLIER shall include the following WORK:

   a. Integrate the PCIS with existing devices and systems provided under this and other Divisions

   b. Prepare the required PCIS submittals

   c. Design and develop project-wide loop diagrams including those associated with equipment provided under other Divisions and OWNER-furnished and existing equipment

   d. Design and develop control panel drawings

   e. Field verify existing conditions

   f. Prepare factory and field test submittals

g. Prepare training plan

h. Prepare spare parts submittal

i. Procure hardware and software

j. Configure and factory test the PCIS

k. Bench calibrate instruments and verify calibration after installation

l. Terminate signals inside control and network panels; terminate communication and network devices and nodes

m. Supervise and coordinate installation and termination of field signals, power, and utilities associated with the PCIS. Resolve signal, power, or functional incompatibilities between the PCIS and new and existing interfacing devices.

n. Loop test in accordance with the loop diagrams. Validate and certify loops

o. Oversee, document, and certify system commissioning

p. Conduct system performance test

q. Prepare technical manuals

r. Conduct training classes

s. Prepare PCIS as-built final construction drawings

5. Any SYSTEM SUPPLIER responsibilities in addition to the list above are at the discretion of the CONTRACTOR and the SYSTEM SUPPLIER. Additional requirements in this Section and throughout Division 40 that are stated to be the CONTRACTOR's responsibility may be performed by the prequalified SYSTEM SUPPLER if the CONTRACTOR and SYSTEM SUPPLIER so agree.

B. RELATED WORK AND REQUIREMENTS SPECIFIED ELSEWHERE

1. All electrical work required under this section shall conform to the requirements of this Section and the applicable requirements of the Sections in Division 01, Division 26 and Division 27.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of other requirements of these Specifications, all WORK specified herein shall conform to or exceed the applicable requirements of the referenced documents to the extent that the requirements therein are not in conflict with the provisions of this Section; provided, that where such documents have been adopted as a code or ordinance by the public agency having jurisdiction, such code or ordinance shall take precedence.

B. Definitions

1. SYSTEM SUPPLIER**:** The SYSTEM SUPPLIER shall be a single firm, corporation, or other entity assuming full responsibility through the OWNER to perform all engineering and to select, furnish, program, configure, integrate, supervise the installation and connections, test, calibrate, and place into operation all instrumentation, controls, communication hardware and software. The SYSTEM SUPPLIER shall specialize and have an experienced engineering and technical staff in the design, integration, and supply of systems like the one in these Contract Documents. The term "SYSTEM SUPPLIER" shall mean the same as "SCADA System Supplier" or "PCIS Supplier.

C. The PCIS WORK shall conform to or exceed the applicable regulations, standards, specifications, and codes which are referenced in Section 01 42 19 Reference Standards, and current as of the date of the final inspection for this Contract, including, but not limited to, those which are established by the following sources:

1. The International Society of Automation (ISA)
2. National Electrical Code (NEC)
3. National Fire Protection Association (NFPA)
4. Institute of Electrical and Electronic Engineers (IEEE)
5. Occupational Safety and Health Administration (OSHA)
6. American National Standards Institute (ANSI)
7. National Electrical Manufacturers Association (NEA)
8. Insulated Cable Engineers Association (ICEA)
9. Local Power and Telephone Companies
10. Local Authorities having jurisdiction over the work
11. Federal Communication Commission (FCC)
12. Underwriter Laboratory (UL)

D. Where the requirements set forth in these Specifications or on the Drawings are greater or more rigid than the mandatory requirements referenced above, the applicable Specifications or Drawings shall govern.

E. In the case of conflict between any mandatory requirements and Specifications or Drawings, the mandatory requirement shall be followed in each case, but only after submitting such proposed changes to the ENGINEER for approval.

F. Nothing contained in these Specifications or shown on the Drawings will be so construed to conflict with any national, state, municipal, or local laws or regulations governing the installation of work specified herein, and all such acts, ordinances, and regulations, including

the National Electrical Code, are hereby incorporated and made a part of these Specifications. All such requirements will be satisfied by the CONTRACTOR at no additional expense to the OWNER.

G. The Drawings and Specifications are complementary to each other; what is called for by one shall be as binding as if called for by both. If a conflict between Drawings and Specifications is discovered, this shall be referred to the ENGINEER as soon as possible for resolution. Should a conflict exist between the Drawings, Specifications, and/or mandatory requirements (i.e., codes, ordinances, etc.), it will be assumed that the more expensive method has been estimated, unless such alternate has been agreed to prior to submission of bids.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Presubmittal Conference

1. The CONTRACTOR shall arrange and conduct a Pre-submittal Conference within 30 Days after award of the Contract. The purpose of the Pre-submittal Conference is to review and approve the manner in which the CONTRACTOR intends to carry out its responsibilities for Shop Drawing submittal on the WORK to be provided under this Section. The SYSTEM SUPPLIER and the ENGINEER shall attend. Both the CONTRACTOR and the ENGINEER may invite additional parties at their discretion.

2. Before preparing the submittals, the CONTRACTOR shall meet with the OWNER and visit the project site(s) to obtain information and inventory regarding the existing conditions. Interface to existing equipment, control and monitoring circuits shall also be reviewed. During the inventory the CONTRACTOR shall determine the location of the new equipment that is part of this contract. Any major conflicts with the contract documents shall be brought to the ENGINEER's attention at the pre-submittal conference The CONTRACTOR shall also review the available as built drawings.

3. The CONTRACTOR shall allot 4 hours for the pre-submittal conference.

4. The CONTRACTOR shall present the following for discussion at the pre-submittal conference:

a. A list of equipment and materials required for the PCIS and the manufacturer's name and model number for each proposed item.

b. A list of requests for clarifications (RFC) or information (RFI) to the contract documents along with a brief explanation of each. Resolution shall be subject to a separate formal submittal and review by the ENGINEER.

c. An exact one-to-one sample of each type of submittal herein.

d. A bar-chart type schedule for system-related activities from the Pre-submittal Conference through start-up and training. Dates of submittals, design, fabrication, programming, factory testing, deliveries, installation, field testing, and training shall be shown. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule.

5. The CONTRACTOR shall take minutes of the pre-submittal conference, including events, questions, and resolutions. Prior to adjournment, attendees must concur with the accuracy of the minutes and sign accordingly.

1.4 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

A. The CONTRACTOR shall provide submittals in accordance with Section 01 33 00- Contractor Submittals and the additional submittal requirements specified in this Section, in Division 40, and the following:

1. The CONTRACTOR shall coordinate the PCIS part of the WORK so that a complete instrumentation and control system will be provided and will be supported by accurate Shop Drawings and as-built drawings.

2. The submittals and their schedules shall be in accordance with the requirements listed below: Any incomplete submittal will be rejected and returned without comments.

3. Interface between instruments, VFDs, flowmeters and other equipment related to the PCIS shall be included in the shop drawing submittal. Interface between existing equipment, instruments and control panels shall also be included,

4. Exchange of Technical Information: During the period of preparation of these submittals, the CONTRACTOR shall authorize a direct, informal liaison with the ENGINEER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as indicated may be authorized informally by the ENGINEER but will not alter the scope of WORK or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the ENGINEER shall be construed to give approval of any component or method, nor shall any statement be construed to grant exception to or variation from these Contract Documents.

5. Symbols and Nomenclature: In these Contract Documents, systems, meters, instruments, and other elements are represented schematically, and are designated by symbols as derived from Instrument Society of America Standard ISA S5.1 - Instrumentation Symbols and Identification. The nomenclature and numbers designated herein and, on the Drawings, shall be employed exclusively throughout Shop Drawings, and similar materials. No other symbols, designations, or nomenclature unique to the manufacturer's standard methods shall replace those prescribed above, used herein, or on the Drawings.

B. Shop Drawings Submittal Organization

1. Shop Drawings shall include the letter head or title block of the SYSTEM SUPPLIER. The title block shall include, as a minimum, the SYSTEM SUPPLIER's registered business name and address, project name, drawing name, revision level, and personnel responsible for the content of the drawing.

2. Organization of the Shop Drawing submittals shall be compatible with eventual submittals for later inclusion in the Technical Manual. Submittals not so organized will not be accepted.

3. For a project with multiple sites the CONTRACTOR shall provide a separate and unique set of drawings for each site.

4. Drawings that require more than one sheet due to space limitation or continuation in the subject of the drawings (e.g. loop diagrams, etc.) shall be given the same drawing number but with different sheet number (e.g. sheet 1 of x, sheet 2 of x, etc.).

5. Each submittal shall include a complete index appearing in the front of each bound submittal volume. Drawings and/or system groups shall be separated by labeled tags. The organization of the initial shop drawing submittal required above shall be compatible to eventual inclusion with the Technical Manuals submittal and shall include final alterations reflecting as-built conditions.

6. Interfaces between new and existing instruments, motor starters, variable speed drives, flow meters, chemical feeders, panels, and other equipment related to the PCIS shall be included in the Shop Drawing submittal.

C. Field Instrument Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete field and process instrument submittal, **all at one time, within 60 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR.

2. Submittal Contents: The submittal shall include a complete index which lists each device by tag number, type, and manufacturer in accordance with the specified data sheets provided in this CONTRACT. A separate manufacturer technical brochure or catalog sheet shall be included with each specified instrument data sheet. If, within a single system or loop, a single instrument is employed more than once, one manufacturer brochure or catalog sheet may cover multiple identical uses of that instrument in that system. Each manufacturer brochure or catalog sheet shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags. Special options and features which are furnished shall be identified.

D. System Hardware Submittal:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete system hardware submittal, **all at one time, within 90 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. This submittal shall be submitted together with the submittal for the System Architecture, and Communication Diagrams submittal and the Project-Wide Wiring Diagrams and Panel Drawings submittal specified below.

2. Submittal Contents:

a. The submittal shall be for the hardware specified under Sections 40 95 10 – PLC - Based Control System Hardware and 40 95 13 - Control Panels.

b. The submittal shall include a complete index which lists each device by type, and manufacturer in accordance with the contract documents. A separate manufacturer technical data sheet or brochure shall be included for each hardware component. If, within a single system a single component is employed more than once, one manufacturer technical data sheet or brochure may cover multiple identical uses of that component in that system. Special options and features which are furnished shall be identified.

c. The submittal shall include load calculations and size of the various UPS systems to demonstrate that the UPS is able to accommodate present and future load requirements, as well as overload capacity requirements.

d. Spare Parts and Tools List: A list of spare parts and tools shall be submitted, covering items which are specified and furnished under this Contract. The list shall include the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts. The list shall also include recommended spare parts and tools, quantities and prices from which the OWNER will select the "Additional Recommended Spare Parts and Tools".

E. System Software Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete system hardware submittal, **all at one time, within 90 calendar days** after the date of Notice to Proceed

2. Submittal Contents:

a. The submittal shall be for the software specified under Section 40 95 20 – PLC-Based Control System Software. This submittal shall be provided in a singular all inclusive submittal and be made separately from other PCIS submittals.

b. The software submittal shall include but not be limited to:

1) Vendor documentation that supports that the specific functional requirements of the contract documents Section 40 95 20 – PLC-Based Control System Software are met. Details shall include complete description of the standard (baseline) application Human Machine Interface (HMI) software programs, operating system and utility programs to be furnished, including modifications and explanation of how the specific functional requirement will be met. A cross reference between the specification and the software submittal shall be provided in order to provide the ENGINEER the ability to identify how each specified section or function is being met by the CONTRACTOR.

2) A functional design report of the implemented control functions using as a reference the strategies specified in Section 40 90 10 – Control Strategies. The report shall include:

a) Control narratives and their implementation, which describe all monitoring and control functions (e.g., commands, mission, anticipated

action, etc.) on a loop by loop or site by site basis in the PLC. It shall also describe special control functions in the server(s), including peer-to-peer communication. These narratives will be used for the operating instructions and inclusion in the Operations and Maintenance Manuals.

b) Control narratives shall enumerate the signal point name, signal description, associated PLC number, associated graphic displays, system functions activated by the signal (i.e., interlocks, alarms, logs, etc.)

c) A complete set of all available software algorithms with annotation of:

1) Individual coil register and variable description

2) Program, group of program, subroutine, and complete rung detail comments

3) Memory, coil, register, and variable usage mapping

d) Description of how the HMI software will be configured to meet the requirements specified in Section 40 95 20 – PLC-Based Control System Software.

e) Electronic copies of the configured PLC control software shall be provided.

F. Input and Output (I/O) Data List:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete I/O list(s), **all at one time, within 90 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR.

2. Submittal Contents:

a. The submittal shall include a complete listing of the PCIS I/O data base listing for each data point relevant parameters such as range, active state, contact orientation, limits, incremental limits, and I/O hardware address. The list shall be divided and grouped on a site by site basis and PLC assignment, and divided into type of I/O's (card type). The I/Os shall be identified by the location of the card (slot no.) and input/output point number. The I/O list shall be formatted in MS Excel.

b. In addition to the active I/O's, the list shall also include the implemented spare I/O's and the available I/O's remaining on the I/O board.

G. System Architecture and Communication Diagrams

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete set of system architecture and communication diagrams **all at one time within 90 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. This submittal shall be submitted together with the System Hardware submittal and the Project-Wide Wiring Diagrams and Panel Drawings submittal specified herein.

2. Submittal Contents: System Architecture and Communication System Diagrams: The CONTRACTOR shall develop and submit project-wide system architecture and communication diagrams, which present the system architecture, the network(s), and radio communication as applicable. The submittal shall include a set of drawings that presents the following as applicable:

    a. System architecture and network (copper and fiber optic) physical topology schematic, including applicable servers, workstations, hardware nodes, network hardware such as routers, cabling converters, etc., and connections.

    b. Radio communication, cabling and connections included within panels and the antenna.

H. Project-Wide Wiring Diagrams and Panel Drawings Submittal:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete set of project-wide wiring diagrams (PWWD) and panel drawings, **all at one time within 120 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. The PWWD and panel drawings shall be a singular complete hard copy bound package and accompanied with a PDF on a CD. This submittal shall be submitted together with the System Hardware submittal and the System Architecture and Communication Diagrams submittal specified herein.

2. Submittal Contents: The PWWD and panel drawings shall be submitted as a single and comprehensive set of drawings. The submittal shall include a complete index in the front of each part of the submittal. The drawings shall be indexed by systems, sites, or process areas. Diagrams shall be tagged in a manner consistent with the Contract Documents and shall include the following:

    a. Project-Wide Wiring Diagrams: The PWWD shall define and document the contents of each analog and discrete monitoring, alarming, hardware interlock, and control functions associated with equipment provided under Division 40 sections. The PWWD shall also cover equipment provided under sections in other Divisions, existing, and OWNER-furnished equipment. The PWWD shall also include both field and panel wiring diagrams.

        1) Drawings showing definitive diagram for every analog and discrete instrumentation loop system. These diagrams shall show and identify each component in each loop or system using legend and symbols from the standards in the Contract Documents. The wiring diagrams shall be presented on an 11"x17" drawing with no more than 10 loops per drawing.

        2) In general, loops shall be grouped and organized by PLC (if used) and the I/O cards within the PLC. Each I/O card shall be presented on a separate sheet(s) and on the right side of the drawing. The type of card, part number and its slot location shall be identified. Each I/O shall be identified as well as its location on the card and its address. Existing, spare, and future I/Os shall also be shown. Power supply wiring to the card/loops, wire colors, and terminal numbers shall be shown on the wiring diagrams. The I/O cards, the loops and any device in the loop shall be shown together. Each loop shall be complete,

including the source/destination within new or existing panels, device(s) in the loop, field connection panels or field junction boxes, field and PLC interface terminal blocks and wire numbers.

3) In addition, wiring diagrams shall show the following details

a) Functional name of each loop

b) Reference name, drawing, and loop diagram numbers for any signal continuing off the wiring diagram sheet.

c) Lighting panel, circuit, and breaker numbers for power feeds to the loops and instrumentation.

d) Wiring type, size, and color

e) Designation, and if applicable, terminal assignments associated with every manhole, pull box, junction box, conduit in which wiring is to be located, and panel through which the loop circuits pass.

f) Vendor panel, instrument panel, conduit, junction boxes, equipment and PLC terminations, termination identification wire numbers and colors, power circuits, and ground identifications.

4) Wiring diagrams shall be developed for loops in equipment vendor-supplied packages, equipment provided under Division 40, and OWNER-furnished equipment.

b. Panel Wiring Diagrams: Panel wiring and/or piping diagrams shall be prepared in concert with the PWWD and shall include the following information:

1) Name of panel

2) Power distribution schematic diagrams associated with each panel or system (120VAC, 24VDC and other DC systems, control circuits). The schematic diagram shall show source of power for the panel (circuit breaker panel and breaker) and fuses. All power backup system distribution shall also be shown.

3) Schematic diagrams for control circuits in accordance with ANSI standards. The diagrams shall show complete details on the circuit interrelationship of all devices within and outside each Control Panel. Including primary measurement and control devices.

4) Communication diagram(s) for the equipment inside the panel.

5) Interfaces with existing control and monitoring systems. The CONTRACTOR shall furnish all necessary diagrams that depict any and all modifications made to existing measurement and control circuits, equipment and wiring. It is the responsibility of the SYSTEM SUPPLIER to ascertain actual field conditions of the existing circuits, equipment and wiring. The CONTRACTOR may request copies of as built drawings and data that the OWNER can provide

that show such existing conditions. Lack of such drawings shall not alleviate the contractual responsibility to ascertain and implement interfaces and modifications to existing measurement and control circuits, equipment and wiring.

6) Surge protection and signal and safety grounding circuits

7) Wiring type and piping size and material

8) Terminal block numbers and wire numbers

c. Panel Drawings: Panel drawings, including console, and cabinet layout drawings, shall be prepared and submitted for each panel and shall include the following information: These drawings shall include enough other details to define exactly the style, the contents, and overall appearance of the panel assembly.

1) Name of Panel.

2) Panel Dimensions; front, side, and plan views and layout to scale.

3) Arrangement of internally and externally mounted instruments and equipment to scale. Note: Control panel layouts shown on the Contract Drawings are diagrammatic.

4) Location of terminal blocks, electrical devices, and conduit entry location(s).

5) Tag number or item number and functional name of items mounted in and on panel, console, or cabinet.

6) Nameplate legend which includes text, letter size, and colors to be used.

7) Complete and detailed Bills of Materials shall include all items within a panel and shall be presented on the panel layout drawing. The bill of material list shall include quantity, description, manufacturer, and part number.

8) Panel mounting information, including conduit entrance location.

9) Communication hardware installation, such as radio, mast, and antenna.

10) Assembly and construction drawings. These drawings shall include dimensions, identification of all components, construction material and gauge, surface preparation and finish data, panel door locks and hinge mechanism, nameplates, and the like.

I. Display and Report Submittals:

1. Submittal Schedule:

a. After all Software Submittals have been approved by the ENGINEER, but **30 calendar days** prior to the requisite Graphics and Report Meetings, the SYSTEM

SUPPLIER shall submit a PDF set of the graphic displays, trend displays, and periodic reports for review by the ENGINEER and OWNER.

b. Required periodic reports for effluent or reuse shall be provided in coordination with the Owner.

c. This submittal shall be prepared and submitted 30 calendar days after the requisite Graphics and Report Meetings specified in Section 40 95 20 – PLC-Based Control System Software.

2. Submittal Contents:

a. The CONTRACTOR shall refer to the specified Graphic meetings No.1 and 2 in Section 40 95 20 - PLC-Based Control System Software.

b. Displays: All workstation displays (graphics and trends) submittals shall be in full color as they will appear on the monitor. Locations for process data shall be clearly identified either using simulated data or by showing variables on the displays and providing a reference list describing those variables. All dynamic points shall be identified by tag number as a minimum and their operation shall be described on separate sheets (color change, symbol change, etc.).

c. Reports: Sample reports of each type shall be submitted in the format established in the Graphics Meeting. The reports shall use simulated data.

J. Fiber Field Test Results and Report Submittal

1. Submittal Schedule: The SYSTEM SUPPLIER shall submit for approval fiber test results and report **complete within 14 calendar days** after receipt of the approved communication test procedure.

2. Submittal Contents: The report shall present the results of the fiber test and the completed forms.

K. Factory Test Procedure Submittal:

1. Submittal Schedule: The SYSTEM SUPPLIER shall submit for approval a comprehensive factory acceptance test (FAT) procedure **complete within 180 calendar days** after the date of Notice to Proceed is given to the SYSTEM SUPPLIER, but not later than **60 calendar days** prior to the Factory Acceptance Test date.

2. Submittal Contents:

a. The SYSTEM SUPPLIER shall develop and submit factory test procedures to show that the integrated system hardware and software is fully operational and in compliance with the requirements of the Contract Documents. (Also see "Quality Assurance" paragraph in this Section and Section 40 95 20 – PLC-Based Control System Software.

b. The FAT procedures shall include the following tests to be conducted:

1) Hardware review and inventory

2) Panel computer system(s) start-up

3) Panel Computer Security

4) Navigation and operator's commands

5) Database definition and configuration

6) Graphic displays and editing function

7) Monitoring and alarm features and functions

8) Trending functions

9) Reports and report system functions

10) Network Communication and access from all the network nodes

11) PLC functionality – I/O processing

12) Process PLC and HMI operation including pump control

c. Procedure Format: The test procedure shall have a table of contents and each procedure shall be provided on a separate sheet or sheets. The following shall be provided for each procedure:

1) Test number

2) The purpose of the test

3) The procedure

4) The expected result

5) Space to indicate "Pass" and "Fail" and explanation

6) Space for sign-off Signature for the CONTRACTOR, the ENGINEER, the OWNER, and DATE

7) Space to provide comments and punch list items

L. Startup and Commissioning Submittals

1. Submittal Schedule: The CONTRACTOR shall submit for approval a proposed procedure to be followed during startup and commissioning of the PCIS and its components no later than **60 calendar days** prior to the Factory Acceptance Test date.

2. Preliminary Submittal: Outlines of the specific procedures and examples of proposed forms and checklists.

3. Detailed Submittal: After approval of the Preliminary Submittal, the CONTRACTOR shall submit the proposed detailed procedures, forms, and checklists. This submittal shall include a statement of objectives with the test procedures.

M. Training Plan and Training Manual Submittals:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a training plan and a training manual submittal no later than 3**0 calendar days** prior to start of the first training session.

2. Submittal Contents: The Training submittal shall consist of two parts:

a. Training Plan, which shall include:

1) Schedule of training courses including dates, durations, and locations of each class. Number of times each class will be offered, if applicable and the number of people expected in each class.

2) List of courses and lessons and who will conduct them

3) Resumes of the instructors who will conduct the training classes. The CONTRACTOR shall identify in the submittal the courses and lessons that will be performed by the equipment manufacturer.

4) List of material used for the training, which shall include the Technical Manuals for the PCIS.

b. Training Manual

1) Training subjects' syllabus and associated lesson plans. The training subjects are listed in Part 3 "Execution "of this Section. If, in the opinion of the SYSTEM SUPPLIER, additional subjects that are not listed and are pertinent to the training and will benefit the OWNER's staff, these subjects shall also be included in the training manuals and taught in the class.

1.5 CLOSEOUT SUBMITTALS

A. Technical Manuals Submittal

1. Submittal Schedule:

a. The CONTRACTOR shall submit for approval Technical Manuals for the PCIS: Initial set shall be submitted at least **60 days** prior to the starts of the OWNER's training.

b. Each set shall consist of one (1) or more volumes and provided in PDF. In addition, a hard copy of the technical manual shall be provided in bound standard size, 3-ring, loose-leaf, vinyl plastic hard cover binders, suitable for bookshelf storage. Binder ring size shall not exceed 3 inches.

2. Submittal Contents:

a. Information in the Technical Manual shall be based upon the approved Shop Drawing submittals as modified for conditions encountered in the field during the WORK. The Technical Manuals shall therefore contain the as-built drawings and information.

b. The Technical Manuals shall include installation, connection, operating, calibration, set points (e.g., pressure, pump control, time delays, etc.) adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.

c. The Manuals shall have the following material organized in volumes and divided by subject and tabs The Technical Manual shall have the following organization for each process (the number and the enumeration of the sections shall be project specific):

1) Section A - Process and Instrumentation Diagrams (as built copy)

2) Section B - System Architecture and Diagram

3) Section C - Wiring Diagrams. A separate set of drawings shall be provided for each site. Each set shall be arranged in a separate tab (drawings shall also be provided in PDF).

4) Section D – Functional design report. It shall include a copy of the site graphic display(s) and description how the site is controlled and any special control strategies. Special control functions in the existing server that apply to this project shall also be included. Calibration, set points (e.g., pressure, pump control, time delays, etc.) shall also be included.

5) Section E - Instrument Data Sheets and corresponding manufacturer's data sheet/catalog cuts/brochure that was used in the hardware submittal and the operation and maintenance/user manual.

6) Section F - Calibration Documentation

7) Section G – Communication survey and test results

8) Section H - Loop, Commissioning and Performance Test Results

d. System User Manual: Its purpose is to provide an operator a manual how to use the SCADA system hardware and software and the HMI. The user manual shall be a separate binder and, as a minimum, shall include, but not limited to:

1) System Architecture Diagram with names and locations of major components

2) System access assignment procedures and security level assignment and their privileges and limitations

3) Navigation Bar/Buttons instructions (alarms, navigation buttons, maps, username, login procedure, site summary, communication, etc.)

4) Menus

5) Description of Graphic Standards Used (colors, symbols, etc.)

6) List of display screens, trends, and reports, with display name and description.

7) Procedures during system start-up, fail-over, and recovery

8) A list of the control screens with the display names and description. It shall also provide a summary of possible commands and operator inputs to these screens including set points. All control actions shall be included

9) Alarms: screen, maintenance, historical, messages, operator commands, etc.

10) Report data format and scheduling; procedures to change formats and scheduling. Instructions for manually printing screens or reports, both real time and historical as applicable.

11) Procedure to manually backup HMI software application and data files.

e. Software Manual: This manual shall be devoted exclusively to the control system software and the PLC programming. In addition to the requirements specified in Section entitled CONTRACTOR Submittal, this manual shall contain complete documentation of the software programs provided, including listings, database, communication protocol(s), annotated PLC programs, and all as necessary to maintain, troubleshoot, modify, or update the all the software systems such as application software and PLCs. It shall also include:

1) All program manuals and electronic media supplied by the manufacturers with the standard software packages the source code of all high-level program language which is specifically created by the CONTRACTOR for this project.

2) All PLC program and panel mount computer configuration program files stored on electronic media. The PLC program and computer configuration files on electronic media shall also be updated as required if any changes or corrections are required in this programming prior to project completion.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. The CONTRACTOR shall provide the specified spare parts and tools. In addition, The ENGINEER and the OWNER will select from the priced list of "Additional Recommended Spare Parts" in the Hardware Equipment Submittal. The CONTRACTOR shall furnish these parts and will be paid for them from the corresponding allowance item in the Bid. The total price will not exceed the amount of the allowance item.

B. The CONTRACTOR shall furnish a priced list of special tools required to calibrate and maintain the instrumentation provided from which the ENGINEER or the OWNER will select the needed tools. After approval the CONTRACTOR shall furnish tools on that list. The cost of these tools will be included in the allowance.

1.7 QUALITY ASSURANCE

A. Factory Acceptance Tests (FAT):

1. Prior to shipment, the PCIS including all panels, integrated SCADA system, PLCs, peripherals, communications equipment, etc. provided under this Division, shall be assembled, connected, and all software loaded for a full functional factory acceptance test (FAT) of the integrated system. Existing equipment is not required to be included in this test.

2. In preparation for the FAT, the CONTRACTOR shall check, troubleshoot, debug and test the PCIS prior to arrival of the ENGINEER in order for the PCIS to be ready for the FAT, minimize testing time, and minimize re-testing during the visit. Similar testing shall be performed even if the ENGINEER chooses not to witness the FAT.

3. The CONTRACTOR shall allow the ENGINEER and OWNER to inspect the PCIS and witness the functional testing of the system at the site of assembly and integration of the system.

4. A minimum of 21 Days notification shall be given to the ENGINEER prior to testing. No shipments shall be made without the ENGINEER's approval. A successful completion of the test is a prerequisite to the shipment of the system.

5. The factory test will be witnessed by the ENGINEER (1 person) and the OWNER (up to 3 people). The SYSTEM SUPPLIER shall pay and provide for travel, food, and lodging for all the test witnesses.

6. The factory acceptance test shall be conducted at the place where the system was engineered, fabricated, assembled, and programmed.

7. It is considered reasonable that once scheduled, the system will be ready for the test and the test will be successfully completed in one session. If during the test, at the opinion of the ENGINEER and in accordance with the test procedure, the system is not ready for the test or has failed, and the ENGINEER and the OWNER must extend their stay or leave and arrive at another date, the OWNER reserves the right to withhold monies due to the SYSTEM SUPPLIER to cover additional costs of the ENGINEER’s time, travel, food, and lodging and associated project cost.

8. During the factory acceptance test, the SYSTEM SUPPLIER’s Project Manager and software engineers (HMI application software and PLC programming) who worked on the PCIS shall be available on the premises where the test is being conducted for explanation, demonstration or corrections.

9. After the successful completion of the test, the ENGINEER will generate a punch list. The list may include items that must be corrected or addressed prior to the shipment of the system, and/or items that must be corrected later in the field during installation and startup.

10. PLCs shown in the network architecture diagram shall be included in the factory test as representatives of the system. Vendor PLCs may be simulated.

B. Field Tests: The CONTRACTOR's attention is directed to the Article "EXECUTION" of this Section which delineates all the tests that are required to be performed in the field in order to demonstrate compliance with the Contract Documents.

C. The CONTRACTOR shall provide and assign to the OWNER all user software and hardware licenses. Computer and software system shall be purchased on behalf of the OWNER who shall also be designated as the licensee. Each software package shall be provided with a "Site License" or with as many licenses as a "Site License" includes (site is defined as the name of the OWNER). The CONTRACTOR shall include in the bid price all license fees.

D. The CONTRACTOR shall provide the proper number of software licenses for any additional computers and/or software required to provide concurrent and simultaneous user operation.

E. Prior to final acceptance of the PCIS System and related equipment, the CONTRACTOR shall propose and present in writing to the OWNER a one-year maintenance contract and quotation which will become effective upon the expiration of the warranty. The maintenance contract is an option that the OWNER may purchase from the SYSTEM SUPPLIER. The contract shall offer different maintenance, site visit and help-desk with options each with its respective cost.

1.8 FIELD SITE CONDITIONS

A. The PCIS shall be designed and constructed for satisfactory operation and long, low maintenance service under the following environmental conditions of a wastewater treatment facility.

B. Site Equipment:

1. Ambient temperature range: -18° through 60° C

2. Thermal shock: 1.0° (1.8° F) per minute maximum

3. Relative humidity: 95 percent maximum non-condensing

1.9 WARRANTY

A. All parts, material labor, travel, subsistence, or other expenses incurred in providing services and service visits during the warranty period shall be borne by the CONTRACTOR under the guarantee specified in Division 1. Equipment, software, and materials that do not achieve their intended purpose shall be replaced by the CONTRACTOR to attain compliance, at no additional cost to the OWNER.

B. Extended Period for Correction of Defects: The CONTRACTOR shall correct defects in the PCIS upon notification from the OWNER within 2 years from the date of Substantial Completion. Corrections shall be completed within 5 Days after notification.

C. The performance of the control panel monitor, and panel mount PC hardware shall be guaranteed (repair of parts and labor at the owner's site including travel expenses) for a period of three (3) years following the date of completion and formal acceptance of the work (next business day on-site service).

D. Software Upgrades: During the warrantee period, the CONTRACTOR shall furnish and install at no additional cost to the OWNER any application software upgrades published applicable to OWNER's applications and compatible with OWNER's hardware and operating system.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Standard and Current Technology: All PCIS hardware, software, materials, and equipment furnished under this contract shall be new, free from defects, and shall be standard products and technology produced by manufacturers regularly engaged in the manufacturer of these products. Meters, instruments, and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

The CONTRACTOR shall submit a Substitute Item Request Form in case of discontinued or upgraded product or other cases where changing technology requires changes in equipment or software.

B. Adverse Environmental Impact: No component of an instrumentation system shall contain liquid mercury.

C. Hardware Commonality and Modularity: Instruments which utilize a common measurement principle shall be furnished by a single manufacturer. Panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer. All equipment shall be of modular design to facilitate interchangeability of parts to assure ease of servicing and expandability.

D. Instrument and Loop Power: Power requirements and input/output connections for components shall be verified. Power for transmitted signals shall, in general, originate in and be supplied by the control panel devices. The use of "2 wire" transmitters is preferred, and use of "4 wire" transmitters shall be minimized. Individual loop or redundant power supplies shall be provided as specified and/or as required by the manufacturer's instrument load characteristics to ensure sufficient power to each loop component. Power supplies shall be mounted within control panels or in the field at the point of application.

E. Loop Isolators and Converters: The CONTRACTOR is responsible to resolve any signal level incompatibilities where required.

F. Signal Levels: Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical signals outside control panels shall be 4 to 20 milliamperes DC except as indicated. Signals within enclosures may be 1 to 5 volts DC. Electric signals shall be electrically or optically isolated from other signals. Pneumatic signals shall be 3 to 15 psig with 3 psig equal to 0 percent and 15 psig equal to 100 percent.

G. Alternative Equipment and Methods: Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the ENGINEER through

the "or equal" process of Section 01 25 10 - Products, Materials, Equipment, and Substitutions. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage, and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available.

H. Lightning and Surge Arrestors

1. A lightning and surge arrestor (LSA) shall be provided to protect the electronic instrumentation system from induced surges propagating along the analog and discrete signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation but shall be lower than the instrument surge withstand level and be maintenance-free and self-restoring. The LSA shall be housed in a suitable metallic case, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and where practical, each ground wire run individually and insulated from each other.

2. Protection of field analog, discrete, digital, and telemetered signal lines shall be provided as required. LSA devices shall be installed as close to the instrument being protected as possible.

3. Where signal lines enter or leave control rooms, buildings, etc., through an interface cabinet, the protection devices shall be mounted in the interface cabinet. Protection shall be with the combined use of gas tube surge arrestor and Zener diode protectors, MOV's and capacitors. The LSA shall be modular and plug-in type with an indicator to show LSA status. The LSA shall be compatible with the terminal blocks. The terminal block surge arrestors shall be as manufactured by Emerson (EDCO), WAGO, Phoenix Contact or equal

PART 3 -- EXECUTION

3.1 EXAMINATION

A. Shipping: After completion of shop assembly, factory test, and approval, the tested PCIS equipment, cabinets, panels, and computer hardware shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.

B. Special Instructions: Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

C. Tagging: A permanent stainless steel or other non-corrosive material tag marked with the instrument or equipment tag number shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. Storage: It is the CONTRACTOR's responsibility to assure proper handling and on-site storage of instrumentation and control equipment in accordance with the SYSTEM SUPPLIER's recommendations. All equipment and materials delivered to the jobsite shall be stored in a location which will not interfere with the operations of other contractors or the OWNER. Equipment shall not be stored outdoors. Storage and handling will be performed in manners which will afford maximum protection to the equipment and materials.

E. Equipment shall be stored in dry shelters, including in-line equipment, and shall be adequately protected against mechanical damage. If any apparatus has been damaged, such damage shall be repaired by the CONTRACTOR. If any apparatus has been subject to possible damage by water, it shall be thoroughly dried out and put through tests as directed by the ENGINEER. If such tests reveal defects, the equipment shall be replaced.

3.2 INSTALLATION

A. General

1. All systems and instrumentation, including instrumentation furnished under other Divisions, shall be installed, connected calibrated, tested, started, and placed into operation in accordance with CONTRACT documents under Division 40 and the manufacturers' instructions. The installation shall be coordinated with the ENGINEER and the OWNER. This shall include final integration in concert with equipment specified and provided by others.

2. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all PCIS equipment.

3. The CONTRACTOR shall furnish the services of an on-site engineer to supervise and coordinate installation, adjustment, testing, and start-up of the PCIS. The engineer shall be present during the total period required to affect a complete operating system. A team of engineering personnel shall be at the site for 40 hours to check equipment, perform the tests indicated in this Section, and furnish startup services.

4. Equipment Locations: The monitoring and control system configurations indicated in the contract documents are diagrammatic. The locations of equipment are approximate unless dimensioned. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the OWNER exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the CONTRACTOR shall make such changes without additional cost to the OWNER.

5. The CONTRACTOR shall review the existing site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

6. The Contract Documents identify conduits and instruments required to make a complete PCIS. The CONTRACTOR shall be responsible for providing any reasonable additional or

different type connections as required by parts of the PCIS' specific installation requirements, or as practical.

B. Conduit, Cables, and Field Wiring

1. Conduits, process equipment control wiring, 4 to 20 mA signal circuits, signal wiring to field instruments and to control panels, PLC input and output wiring, and other field wiring and cables shall be provided under Division 26 and without delay to the WORK of Division 40.

2. PLC equipment cables and communication network cables shall be provided under Division 40, but the installation in the field shall be under Division 26.

3. Terminations and wire identification inside PCIS equipment and panels furnished under this or any other Division shall be provided under Division 40.

4. The CONTRACTOR shall supervise, and coordinate installation and termination and identification of field signals, power, and utilities associated with the PCIS. Resolve signal, power, or functional incompatibilities between the PCIS and new and existing interfacing devices.

C. Installation and Connections:

1. Instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements applicable to the Site. Appropriate mounting stands and bracket materials and workmanship shall be provided and shall comply with requirements of the Contract Documents.

2. Existing Instruments that are to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The CONTRACTOR shall provide certification of this WORK prior to reinstallation of each instrument.

3. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation. The CONTRACTOR shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the ENGINEER for approval prior to commencing that WORK. Such changes shall not be a basis of claims for extra WORK or delay.

4. Field Connection Panels and Interface Terminal Blocks: In cases where field I/O wiring has to be extended to a control panel or from enclosures or devices that are removed, the CONTRACTOR shall provide separate enclosures or junction boxes with interface terminal blocks that will serve as a field connection panel (FCP). The FCP and the terminal block shall be shown on the project-wide wiring diagrams.

5. Conduits and/or raceways in building interior locations shall be surface mounted on walls or ceilings wherever possible and run perpendicular and parallel to building lines. Conduits shall not be routed on floors in areas subject to foot traffic. In exterior locations conduit shall be routed below grade.

6. Wires and cables shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically approved by the ENGINEER. Wiring shall be protected from sharp edges and corners.

7. Signal and low voltage wiring shall be run in a separate conduit from power and 120-volt control wiring.

8. Field wiring shall terminate at terminal blocks in the control panel. Field wiring shall not be wired directly to equipment in the control panel except communication and specialty cables that must be wired directly to their respective equipment.

9. Power and signal wires shall be terminated with crimped type lugs.

10. Wires shall be marked clearly with an identification wire number labels that are of a permanent nature. Computer system equipment cables shall be identified and marked for their location at each end of the cable. Computers and peripheral equipment connections/ports shall also be identified as to what cable is connected to its port location.

11. Connectors shall be, as a minimum, watertight.

12. Sensing Lines and Tubing:

    a. Individual tubes shall run parallel and near the surfaces from which they are supported. Supports shall be used at intervals of not more than 3-feet of rigid tubing.

    b. Bends shall be formed to uniform radii with the proper tool without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at panels requiring pipe or tubing entries.

13. Flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.

14. Differential pressure elements shall have 3 valve manifolds.

15. The CONTRACTOR shall verify the correctness of each installation, including polarity of electric power and signal connections. The CONTRACTOR shall certify in writing all discrepancies have been corrected for each loop or system checked out. In addition, the CONTRACTOR shall make sure process connections are free of leaks.

D. Removal of Abandoned Equipment: Unless otherwise specified, all existing equipment in each facility that is no longer required after the new system has been put in service shall be removed and delivered by the CONTRACTOR to the OWNER.

3.3 FIELD QUALITY CONTROL

A. General:

1. Devices provided under Division 40 shall be initially calibrated by the manufacturer at the manufacturer's facility prior to shipment. Following installation, the devices shall be field calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements. The CONTRACTOR shall also field calibrate existing instruments if it is part of a modified loop.

2. Each instrument shall be field tested, inspected, and adjusted to the indicated performance requirement in accordance its manufacturer's specifications and instructions. Any instrument which fails to meet any contract requirement, or, in the absence of a contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER.

B. Calibration Points: During bench and field calibration each instrument shall be calibrated at least at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs and outputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Bench Calibration: Instruments that have been bench-calibrated by the manufacturer shall be verified in the field after installation to determine whether any of the calibrations are in need of adjustment.

D. Field Calibration: Instruments which were not bench-calibrated shall be calibrated in the field to ensure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. Analyzer Calibration: Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. Calibration Sheets: Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:

1. Project name

2. Loop number and site or process name and number

3. Tag number

4. Manufacturer

5. Model number

6. Serial number

7. Calibration range

8. Calibration data: Input, output, and error at 0 percent, 50 percent, and 100 percent of span

9. Switch setting, contact action, and dead band for discrete elements

10. Space for comments

11. Space for sign-off by SYSTEM SUPPLIER and when applicable by the manufacturer and date

12. Test equipment used and associated serial numbers

G. Calibration Tags: A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the ENGINEER. The CONTRACTOR shall sign the calibration sheet when calibration is complete. The ENGINEER will sign the calibration sheet when the calibration and testing has been accepted.

H. Loop Testing: The CONTRACTOR shall test newly installed and modified existing loops for continuity and functionality. The up-to-date wiring diagrams shall be used as reference. The ENGINEER and/or the OWNER shall witness the loop testing.

I. The CONTRACTOR shall notify the ENGINEER of scheduled tests minimum of 30 calendar days prior to the estimated completion date of installation and wiring of the PCIS. After the ENGINEER's review of the submitted loop diagrams for correctness and compliance with the specifications, loop testing shall proceed. The loop testing shall be witnessed by the ENGINEER and/or the OWNER.

J. Control Valve Tests: Control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to ensure that no changes have occurred since the bench calibration.

K. Interlocks: Hardware and software interlocks between the instrumentation and the motor control circuits, control circuits of variable-speed controllers, and packaged equipment controls shall be checked to the maximum extent possible.

L. Loop Validation:

1. Control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the HMI displays associated with the PLC. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested.

2. Accuracy tolerances for each analog network are defined as the root-mean-square (RMS) summation of individual component accuracy requirements. Individual component accuracy requirements shall be as indicated by contract requirements or by published manufacturer accuracy specifications, whenever contract accuracy requirements are not indicated. Each analog loop shall be tested by applying simulated analog or discrete inputs to the first element of an analog loop. For loops which incorporate analog elements, simulated sensor inputs corresponding to 0, 25, 50, 75, and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance

to calculated RMS summation accuracy tolerance requirements. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices. Provisional settings shall be made on controllers and alarms during analog loop tests. Analog loop test data, including calculated RMS summation system accuracy tolerance, shall be documented by the CONTRACTOR on the loop validation sheets. The validation sheets shall be included in the O&M Manuals.

M. Loop Validation and Certification Sheets:

1. Loop Validation: The CONTRACTOR shall prepare loop validation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop validation sheets shall form the basis for operational tests and documentation. Each loop validation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop by the SYSTEM SUPPLIER:

   a. Project name

   b. Loop number

   c. Tag number, description, manufacturer, and model number for each element

   d. Installation bulletin number

   e. Specification sheet number

   f. Loop description number

   g. Adjustment check

   h. Space for comments

   i. Space for loop sign-off by the System Supplier and date

   j. Space for ENGINEER witness signature and date

2. Loop Certification**:** A certified copy of each loop test validation sheet signed by the SYSTEM SUPPLIER, the ENGINEER or the ENGINEER's representative as a witness, with test data entered, shall be submitted to the ENGINEER together with a clear and unequivocal statement that the loops have been tested and the instrumentation in the loop has been successfully calibrated, inspected, and tested.

N. Manufacturer’s Services

1. The CONTRACTOR shall provide jobsite visits and services of a manufacturer’s technical field representative for supervision of the following:

   a. Oversee installation: Supervise installation and connection of all instruments, elements, and components of every system, including connection of instrument signals to primary measurement elements and to final control elements such as VFD, pumps, valves, and chemical systems.

b. Verify that installed instrument and software meet manufacturer's recommendations

c. Certify installation and reconfirm manufacturer's accuracy statement

d. Oversee loop testing, prepare loop validation sheets, and certify loop testing

e. Certify when testing is completed.

f. Training the OWNER's personnel

2. Manufacturer's services shall be furnished for the following equipment:

a. Autosampler

b. Process Analyzers

3.4 PRE-COMMISSIONING

A. General:

1. Pre-commissioning, which is defined in Section 017500 – Equipment Testing and Plant Startup, is basically the demonstration of proper operation of every part in the PCIS with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible. All systems shall be exercised through field operational tests, as a complete PCIS in accordance with the approved test procedures and in the presence of the ENGINEER and/or the OWNER.

2. Pre-commissioning shall commence after completion and acceptance of continuity tests, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with contract requirements.

3. Pre-commissioning Procedures and Documentation: Pre-commissioning and test activities shall follow detailed test procedures and check lists accepted by the ENGINEER. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the ENGINEER, which include calculated tolerance limits for each step. Completion of system pre-commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the ENGINEER with a clear and unequivocal statement that system pre-commissioning and test requirements have been satisfied. The result of the testing shall also include a punch list developed by the ENGINEER.

4. The burden of proof of conformance of the system to specified functions and performance is on the CONTRACTOR. Tests that fail to demonstrate the required operation shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the ENGINEER.

5. The CONTRACTOR shall supply necessary test equipment and technical personnel if called upon to prove accuracy and/or performance, at no separate additional cost to the OWNER, wherever the OWNER or ENGINEER has reasonable doubt or evidence of malfunction or poor performance appears.

6. The CONTRACTOR shall coordinate the scheduling of tests among all parties involved so that the tests may proceed without delays or disruption by uncompleted work. Field operational and functional testing must be successfully completed prior to the start of the 30-day final acceptance test.

B. Operational Validation:

1. Where feasible, system pre-commissioning activities shall include the use of the actual process to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, PLCs, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational.

2. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of process controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

3. Pre-commissioning shall also include the testing of remote sites to verify compliance with all functional requirements and communication specified. The testing shall include manual and automatic control modes, fail-safe and backup control modes, and PLC interlocks and control strategies provided by the SYSTEM SUPPLIER.

C. Loop and Equipment Tuning: Controllers incorporating proportional, integral and/or derivative control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed set point settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.

D. Pre-commissioning Validation Sheets: Pre-commissioning shall be documented on test forms as follows:

1. The validation form, which shall include:

a. Project name

b. Loop number

c. Loop and function description

d. Tag number, description, manufacturer, and data sheet number for each component.

e. Pre-Commissioning Certification - A statement certifying that the contract requirements have been met. It shall also include a listing of instrumentation and control system maintenance and repair activities conducted during the pre-commissioning testing. Acceptance of the instrumentation and control system testing must be provided in writing by the ENGINEER before the performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.

f. Space for sign-off and date by the CONTRACTOR and the ENGINEER.

3.5 COMMISSIONING

A. Commissioning is the verification that the complete WORK functions on an extended basis are in full conformance with the Contract requirements.

B. As part of the commissioning, the entire PCIS shall operate continuously without failure for 30 consecutive days without failure (see test details below), thus extending its operation test longer than the commissioning period specified in Section 017500.

3.6 STARTUP OPERATION

A. General: Startup is defined as testing, demonstrations, and other activities as required to achieve Substantial Completion. Pre-commissioning and commissioning activities, manufacturer's services, certifications of readiness for testing, and troubleshooting, checkout, and shakedown activities must be completed before startup activities begin.

B. When all equipment and systems have been assessed by the CONTRACTOR to have been successfully carried through complete operational and functional tests with not less than a minimum of simulation, and the ENGINEER concurs in this assessment, system startup by the OWNER'S operating personnel can follow.

C. Each facility, process, or site startup shall be performed in accordance with the approved test procedures.

D. Scheduling of startup shall be coordinated by the CONTRACTOR among all parties involved so that the tests may proceed without delays or disruption by uncompleted work. System startup and training and instruction of the OWNER's personnel must be completed a minimum of seven (7) days prior to the final acceptance test.

1. Troubleshooting and Corrections

a. The Contractor shall participate in all start-up activities. If problems occur, the CONTRACTOR and the SYSTEM SUPPLIER shall jointly participate in the diagnosis wiring, control interface, hardware and software problems and correct deficiencies. The Contractor shall be responsible and bear all expenses to diagnose and correct all the deficiencies for work and equipment furnished under this CONTRACT.

b. Existing Instruments, Wiring, and Interface: As specified above, prior to start of the WORK the CONTRACTOR shall request the OWNER to demonstrate that all existing equipment and software that is to be reused or interfaced with in this project works

properly for the intended function. Consequently, if during the calibration, testing, or start up, the Contractor and/or the CONTRACTOR encounters problems with existing instruments, hardware, wiring, or software that have been demonstrated to work, the CONTRACTOR shall notify the Engineer and the OWNER. In this case, the CONTRACTOR and the Owner's representative shall jointly participate in the diagnosis of the problem. The course of action how to correct the deficiency shall be determined jointly by the OWNER, the Engineer, and the CONTRACTOR. The CONTRACTOR shall be compensated for correcting the deficiencies or replacing the equipment.

c. If a problem is found to be a result of the CONTRACTOR's workmanship or equipment and work furnished under this CONTRACT, the CONTRACTOR shall be responsible and bear the expenses for correcting the deficiencies.

3.7 FINAL ACCEPTANCE TEST (COMMISSIONING)

A. After the pre-commissioning, functional tests, and startup have been completed, the CONTRACTOR shall submit a report/letter stating that the CONTRACT requirements have been met and the PCIS is ready for the Final Acceptance Test.

B. The entire PCIS shall go through a final 30-day acceptance test. For the purpose of this CONTRACT, the terms "Final Acceptance Test" and "Final Performance Test" are synonymous and are used interchangeably. The 30-day test must be successfully completed prior to the date of and as a condition to substantial completion of the entire project WORK. During the testing period, all system functions shall be exercised, and any system interruption and accompanying component, subsystem, software, or program failure shall be logged for cause of failure, as well as time of occurrence and duration of each failure.

C. The CONTRACTOR shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements. The CONTRACTOR shall also provide a competently programmer on call during all normal working days and hours from the start of the acceptance test until final acceptance of the system. The on-call programmers shall be ready to respond within two hours of the notification of the problem.

D. Testing: The entire PCIS shall be tested and shall include, but not limited to, the field instrumentation, control and PLC panels and PLC programs, application SCADA software, graphics and trends, reports, and the control and monitoring functions. Each system function, e.g., status report-backs, alarms, logs, and displays shall be exercised several times at a minimum, and in a manner which approximates "normal" system operation. At least two displays and reports shall be generated during the test.

E. Failure During Testing: Failure of the system during the testing shall be considered as indicating that part of the PCIS does meet the requirements of the specifications and corrective action shall be required before restarting the acceptance test.

Failures shall be classified as either major or minor as follows, and it is at the discretion of the ENGINEER how to classify the failure:

1. Minor Failure: A minor failure would be a small and non-critical component failure which can be corrected by the OWNER's operators. This occurrence shall be logged but

shall not be reason enough for stopping the test and shall not be grounds for non-acceptance or restart, provided that the function(s) can be provided by backup equipment and repairs can be made and equipment returned to service within one (1) working day.

However, should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance and termination of the test.

2. Major Failure: A major failure shall be considered to have occurred when a major component of the PCIS, subsystem, communication, or program fault causes a halt in operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system. A major failure shall cause termination of the acceptance test. When the causes of a major failure have been corrected, a new acceptance test shall be started.

F. Technician Report: Each time a technician is required to respond to a malfunction in the PCIS he/she must complete a report which shall include details concerning the nature of the complaint or malfunction and the resulting repair action required and taken. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report shall be required (logged as specified above). Each report shall be submitted within 24 hours to the ENGINEER or its representative, and the OWNER.

3.8 CLOSEOUT ACTIVITIES

A. Training:

1. The CONTRACTOR shall train the OWNER'S personnel on the PCIS operation, maintenance, calibration, and repair of equipment provided under this Contract. The training shall be by qualified instructors. The training courses shall be given on-site to a minimum four (4) OWNER's personnel. All instruction, tools and training material shall be provided by the CONTRACTOR.

2. These courses shall be designed to provide the operations, maintenance, and supervisory personnel with training in routine and preventive maintenance of all the PCIS including instrumentation, communication, PLCs software, and HMI. The training course shall include instruction on the use of all maintenance equipment and special tools provided under the contract.

3. Instructions: The training shall be performed by qualified instructors. The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

4. Training Manuals and Material: The CONTRACTOR shall use the approved Training syllabus and Training Manuals to develop training material. The training material shall be designed to provide the operations, maintenance, and supervisory personnel with training in routine operation procedures, and preventive maintenance and troubleshooting of the PCIS, PLCs and the computer monitoring and control systems.

5. Schedule: Training shall be performed on-site during the calibration, loop and functional testing of the PCIS prior to the 30-day Final Acceptance Test. The training sessions shall

be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The ENGINEER will review the course outline for suitability and provide comments that shall be incorporated. Due to availability and scheduling of the OWNER's staff, the CONTRACTOR shall coordinate with the OWNER the schedule of the classes. The OWNER reserves the right to videotape the training sessions for later use. Due to possible limited availability of the OWNER's staff, the CONTRACTOR shall provide the number of identical courses/sessions of each of the following training courses as indicated, each up to four (4) people of the OWNER's staff.

6. Training Subjects, Duration, and Agenda**:** The training shall include operation and maintenance procedures, troubleshooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment. During the course, hands-on experience with the system equipment shall be provided. Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the PCIS and the PLCs. Operator classes shall stress operational theory and use of the PCIS and the PLCs.

    a. Field Instruments

        1) Duration – an average of one (1) hour per each type of instrument, unless otherwise noted

        2) Subjects - installation, setup, configuration, maintenance, calibration, and troubleshooting:

            a) Pressure transmitter

            b) Level transmitter

            c) Flow measuring device and transmitter

            d) Analyzer – chlorine and turbidity (2 hours)

            e) Autosampler (2 hours)

            f) Panel devices

            g) OIT and PLC

            h) Uninterruptible power supply (UPS)

7. PLC: The training of the following subject shall be performed by the CONTRACTOR and the PLC manufacturer as noted: Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the PLC. Operator classes shall stress operational theory and use of the PLCs.

    a. Duration – 2 instruction hours or a minimum of 2-hours per class of PLC training.

    b. Subjects:

1) Project specific operation and communication – by the CONTRACTOR

2) Project specific PLC program troubleshooting – by the CONTRACTOR

8. HMI Operation

a. Duration

1) 4 hours for Operations

b. Subjects

1) Report and trend generation

2) Operator training for Reuse Building processes

3) HMI graphics with emphasis on making changes and additions to reports and displays method to be used for scheduling and changing the scheduling of reports.

4) Historical backup and maintenance.

5) Diagnostics, troubleshooting, and related procedures

9. Communication System and Network

a. Duration – 1 hour

b. Subjects –

1) Communication types and communication equipment – radio to reservoir

2) PLC communication hardware

3) Network equipment and maintenance

4) Communication protocols

5) Wireless communication

6) Communication failure diagnosis/troubleshooting and repair

3.9 CRITERIA FOR SUBSTANTIAL COMPLETION

A. For this Section and all Division 40, the following conditions shall be fulfilled before the WORK is considered substantially complete:

1. Submittals have been completed and approved.

2. The PCIS has been calibrated; loop tested, pre-commissioned, commissioned, and the startup completed.

3. The OWNER's training has been performed.

4. Spare parts and expendable supplies and test equipment have been delivered to the OWNER.

5. The Final Acceptance Test has been successfully completed.

6. Major punch-list items have been corrected.

7. As built drawings in both hard copy and electronic format have been submitted. The as built drawings shall also include annotation of the PLC ladder logic program by providing a descriptive label for all relays and function blocks and functional description of each rung.

8. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.

9. Debris associated with installation of instrumentation has been removed.

10. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

END OF SECTION

SECTION 40 91 02
IN-LINE LIQUID FLOW MEASURING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General: The CONTRACTOR shall provide in-line liquid flow measuring systems, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Section 40 91 00 - Process Control and Instrumentation Systems.

B. Applicable Sections in Division 40 and 43 – Instrumentation and Control for Process Systems.

C. Division 26 – Electrical.

D. Section 09 96 00 – Protective Coating

1.3 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

A. Submittals shall be provided in accordance with the requirements specified in Section 40 91 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 MAGNETIC FLOW MEASURING SYSTEMS

A. Manufacturers: The Magnetic flow meter manufacturer and model flow meters shall be as follows and or equal:

1. **Rosemount model 8705 Sensor & 8732E/8712E Transmitter or 8707 Sensor (High Signal)/8712H Transmitter**

2. **Endress+Hauser Proline Promag W 400**

3. **ABB**

4. **Siemens**

5. **Or Equal**

B. Description: Magnetic flowmeter systems shall be the low frequency electromagnetic induction type that produces a DC pulsed signal directly proportional to and linear with the liquid flow rate. .

C. Performance / Design Criteria: Magnetic flowmeter system shall be suitable for the intended service and shall be based on the conductivity properties and solid content of the process fluid, in accordance with the manufacturer's recommendations.

1. Magnetic flowmeter system shall be capable of measuring fluid velocities in the range of 0.04 and 39 ft. /sec. in both forward and reverse flow in all sensor sizes.

2. Accuracy: The flow metering system shall be installed in accordance with the manufacturer's recommendations to provide at least 0.5 percent of flow rate from 10 to 100 percent full scale for velocities over 3 feet per second.

3. Repeatability: 0.1 percent of reading.

4. Power consumption shall be as indicated in the data sheet.

5. Power input requirements shall be as indicated in the data sheet.

D. Materials / Components: The magnetic flow metering system shall include a metering tube, transmitter, and signal cable and flowmeter grounding rings.

1. Metering Sensor/Tube:

a. The metering sensor shall employ a pulsed DC technique to drive flux-producing coils. Sensors using high pulsed DC signals shall be used in accordance with the manufacturer's recommendations for the required service application and as indicated in the data sheet.

b. The metering tube sizes shall be available from at least 1-inch to 36-inch line size. It shall be sized in accordance with the installation application and the intended service and as recommended by the manufacturer, and as indicated in the data sheet. If fractional size or larger size meters are required, the manufacturer shall be consulted for availability.

c. Metering Sensor/Tube

1) Flanged Connections: The flanges' size, style, type and construction material shall be in accordance with the required installation and the intended service application and as recommended by the manufacturer, and as indicated in the data sheet. Pressure ratings shall be as indicated in the data sheet and in accordance with the requirements of Section 40 05 00 – Piping, General as recommended by the manufacturer for the intended service.

2) A minimum of two (2) electrodes shall be provided. The electrodes' material shall be suitable for the required service as recommended by the manufacturer, and as indicated in the data sheet. A reference electrode shall be provided as recommended by the manufacturer for the required installation application.

3) Lining material shall be in accordance with the manufacturer's recommendation for the intended service, and as indicated in the data sheet.

4) Meter housing shall be rated for NEMA 6P (IP68) (limited depth) and shall be offered with certified ratings for different hazardous locations as specified in the data sheet. It shall be able to operate between -20 to 140 Degrees F (-29 to 60 degrees C).

5) Meter tube shall have epoxy protective coating.

6) Grounding rings shall be provided and designed to protect and shield the liner's edge interface from abrasion at the meter end. Grounding rings shall conform to the manufacturer's bore and material recommendation for the intended service Grounding shall conform to the manufacturer's recommendations.

2. Transmitter/Converter

a. The transmitter/converter shall be capable of being mounted integral to the metering tube or remotely as indicated in the data sheet. Mounting hardware shall be provided.

b. The transmitter/converter shall be rated for NEMA 4X (IP67). Certified ratings for different hazardous locations shall be offered as an option as specified in the data sheet. It shall be able to operate in ambient temperatures of -20 to 140 degrees F (-29 to 60 degrees C).

c. The transmitter shall convert the DC pulse signal from the metering tube to a linear 4 to 20 mA DC signal into a minimum of 700 ohms. The 4-20 mADC signal shall comply with HART protocol. Output signal shall be continuously adjustable over the full scale. Other digital output options shall be available.

d. The transmitter shall have an LCD displays for flow rate, percent of span, totalization, operator configuration interface, and diagnostic information.

e. The transmitter shall have an adjustable integral low flow cutoff and zero return.

f. The transmitter shall perform self-diagnostics and automatic data checking and activate a switch closure output when a transmitter fault is detected.

3. Cables

a. Remote transmitter configuration shall be provided with the required lengths and types of electrodes and coil drive cables as recommended by the manufacturer for the required installation application. Maximum distance of transmitter from the metering tube shall be as recommended by the manufacturer.

E. Calibration: Each flow metering system shall be hydraulically calibrated at a facility that is traceable to the National Institute of Standards and Technologies. The calibration procedure shall conform to the requirements of ANS/ISO/IEC 17025:2005 and ANSI/NCSL Z540.3-2006. A real-time computer generated printout of the actual calibration data shall be submitted to the ENGINEER at least 30 Days prior to shipment to the site.

2.2 ROTAMETER LIQUID FLOW MEASURING SYSTEMS

A. Manufacturers: The rotameter manufacturer shall be as follows or equal

1. Water service: **Hedland In-Line Meters, INSITE Meters,** or **McCrometer SK.**

B. Description: Rotameters in chemical solution lines, water, and where required shall be the variable area type and shall have vertical bottom inlets and top outlets with suitable connection for the required installation application as indicated in the data sheet.

C. Performance / Design Criteria: Rotameters shall have a range of 10:1 with an accuracy of plus or minus 2 percent. Meters shall be rated for a minimum working pressure of 150 psi. Flanged rotameters shall be calibrated in gallons per minute, cubic ft. /min, or liters/min, as indicated in the data sheet. Rotameter scale length shall be suitable for the capacity range as indicated in the data sheet.

D. Materials / Components: Rotameter process connection and rating shall be in accordance with the intended installation application as indicated in the data sheet. Rotameter bodies shall have union ends for ease of maintenance with, polysulphone tubes. Fittings, internal parts, and float materials shall be as recommended by the manufacturer for the intended service application and as indicated in the data sheet.

PART 3 -- EXECUTION

3.1 FIELD QUALITY CONTROL

A. In-line liquid flow measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with Section 40 91 00 Process Control and Instrumentation Systems. Manufacturer's service, supervision, and training shall also be in accordance with Section 40 91 00 Process Control and Instrumentation Systems.

END OF SECTION

SECTION 40 91 06
LEVEL MEASURING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General: The CONTRACTOR shall provide level measuring systems, complete and operable in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Section 40 91 00 - Process Control and Instrumentation Systems.

B. Applicable Sections in Division 40 – Instrumentation and Control for Process Systems.

C. Division 26 – Electrical.

1.3 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

A. Submittals shall be provided in accordance with the requirements specified in Section 40 91 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 NON-CONTACTING RADAR TYPE LEVEL MEASUREMENT

A. Manufacturers: Non-contact radar type level measuring systems shall be **Rosemount 5408, Vega model VEGAPULS 6X**, or equal.

B. Description: Radar type level measuring systems shall employ time domain reflectometry (TDR) , utilizing impulses of electromagnetic energy transmitted from the antenna at the tank top down to the liquid level. When the pulse reaches the liquid surface, which has a higher dielectric constant than air, part of the energy is reflected back to the transmitter. The time difference between the transmitted and reflected pulse is proportional to the distance to the liquid surface, from which liquid level and/or volume is calculated.

C. Performance / Design Criteria:

1. Transmitter:

a. Power input to the transmitter shall be as noted in the data sheet. The transmitter shall provide an isolated, 4 - 20 mADC output signal, linearly proportional to level and shall be compatible with digital HART protocol. The unit shall have a local LCD display for configuration and monitoring. Transmitter operating temperature shall be -40 to 175 degrees F.

b. Measuring range shall be as indicated in the data sheet and with a resolution ofplus or minus 0.04-inch.

D. Materials / Components:

1. Transmitter:

a. Transmitter housing material shall be as recommended by the manufacturer for the intended service and as indicated in the data sheet.

2. Antenna and Cone shape material shall be as recommended by the manufacturer for the intended service and as indicated in the data sheet.

3. Transmitter and antenna shall be provided with all the mounting hardware. Mounting type and material shall be as recommended by the manufacturer for the intended service and as indicated in the data sheet and coordinated with the Contractor.

PART 3 -- EXECUTION

3.1 FIELD QUALITY CONTROL

A. Level measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with Section 40 91 00 Process Control and Instrumentation Systems. Manufacturer's service, supervision, and training shall also be in accordance with Section 40 91 00 Process Control and Instrumentation Systems.

END OF SECTION

SECTION 40 91 07
LEVEL DETECTION

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General: The CONTRACTOR shall provide level detection switches, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Section 40 91 00 - Process Control and Instrumentation Systems.

B. Applicable Sections in Division 40 – Instrumentation and Control for Process Systems.

C. Division 26 – Electrical.

1.3 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

A. Submittals shall be provided in accordance with the requirements specified in Section 40 91 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 TIPPING FLOAT TYPE LEVEL SWITCHES

A. Manufacturers: Tipping float type level switch manufacturers shall be **MAGNETROL T10, FLYGT ENM-10, KARI**, **SIEMENS,** or equal.

B. Description: Tipping float level switch shall consist of a switch, a moving float, and a connecting cable that is anchored at the midpoint of a differential band. As the level rises and falls the float rights itself or inverts causing switching actions. The cable anchoring point shall be protected by strain relief.

C. Performance / Design Criteria: The hermetically sealed switches shall have a SPDT output with a minimum rating of 10 Amps at 120 VAC.

D. Materials / Components: The float switch shall be mercury-free. Float material shall be in accordance with the manufacturer's recommendations for the intended service and installation application and as indicated in the data sheet.

PART 3 -- EXECUTION

3.1 FIELD QUALITY CONTROL:

A. Level detection switches shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with Section 40 91 00 Process Control and Instrumentation Systems. Manufacturer's service, supervision, and training

shall also be in accordance with Section 40 91 00 Process Control and Instrumentation Systems.

END OF SECTION

SECTION 40 91 08
PRESSURE MEASURING

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General: The CONTRACTOR shall provide pressure measuring systems, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Section 40 91 00 - Process Control and Instrumentation Systems.

B. Applicable Sections in Division 40 – Instrumentation and Control for Process Systems.

C. Division 26 – Electrical.

1.3 ACTION SUBMITTALS / INFORMATIVE SUBMITTALS

A. Submittals shall be provided in accordance with the requirements specified in Section 40 91 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 PRESSURE GAUGES

A. Manufacturers: Shall be Ashcroft 1279, Ametek Solfrunt Series 1900, or Equal.

B. Performance / Design Criteria: Gauge Protection: Gauges shall be protected with the appropriate components as indicated in the data sheet.

C. Materials / Components:

1. Pressure gauges shall be 4-1/2 inches, with white laminated dials and black graduations, and have either a shatterproof glass or acrylic window as indicated in the data sheet. The gauges' bottom connection size shall be as indicated in the data sheet.

2. Sensing element shall be bourdon tube with welded, stress-relieved joints. Sensing element material shall be as recommended by the manufacturer and as indicated in the data sheet. Gauges shall have an accuracy of plus and minus 1/2-percent of full scale.

3. Body material shall be as recommended by the manufacture and as indicated in the data sheet.

4. Gauge shall be either dry or liquid filled as indicated in the data sheet.

5. Gauges shall be provided with a 316 stainless steel pulsation dampener (snubber), unless otherwise noted in the data sheet. The pulsating dampener shall absorb system pressure pulses.

2.2 ELECTRONIC GAUGE PRESSURE TRANSMITTERS

A. Manufacturers: Electronic Pressure Transmitter Manufacturer shall be Rosemount model 3051TG or 3051CG, Foxboro IGP10 series, Yokogawa EJA series, or Equal.

B. Description: Gauge pressure transmitters shall measure the in-line process pressure using a sensor with sealed fill fluid and isolation/sensing diaphragm. The sensor shall convert the process pressure variations to a linear 4-to-20 mA DC output signal at 24 VDC, 2-wire type, proportional to the pressure variation, with an allowable loop load of not less than 600 ohms. A temperature compensation unit shall also be part of the sensing module.

C. Performance / Design Criteria:

1. Continuously (external) adjustable span, zero and dampening (internal) adjustment.

2. Accuracy shall be at least plus minus 0.14 percent of span.

3. Ambient operating range of minus 40 degree F to plus 250 degrees F.

4. Provide vent, drain, block and bleed valve plugs.

5. Transmitter output shall be compatible with HART protocol.

6. Sensor or transmitter failure alarm - High or low failure mode - shall be provided and shall be user selectable.

D. Materials / Components

1. Sensor fill fluid shall be silicon.

2. Process wetted parts and diaphragm shall be as recommended by the manufacturer for the intended service and installation application and as indicated in the data sheet.

3. As a minimum, housing material shall be 316 stainless steel or as recommended by the manufacturer for the intended service and installation application and as indicated in the data sheet. As a minimum, housing shall be rated NEMA 4X, unless otherwise indicated in the data sheet. Explosion proof rated housing shall be available.

4. Non-wetted parts shall be as recommended by the manufacturer for the intended service and installation application and as indicated in the data sheet.

5. Transmitter shall have an integral digital LCD indicator scaled in linear engineering units.

6. Process connection style shall be ½-inch NPT or flange. Connection style and flange size rating and material shall be as recommended by the manufacturer and as indicated in the data sheet for the intended service and installation application.

7. Provide mounting hardware suitable for the intended service and installation application (e.g., surface mounting, 2-inch pipe, etc.)

PART 3 -- EXECUTION

3.1 FIELD QUALITY CONTROL

A. Pressure measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with Section 40 91 00 Process Control and Instrumentation Systems. Manufacturer's service, supervision, and training shall also be in accordance with Section 40 91 00 Process Control and Instrumentation Systems.

END OF SECTION

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SECTION 40 91 09
PRESSURE DETECTION

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General: The CONTRACTOR shall provide pressure detection switches, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Section 40 91 00 - Process Control and Instrumentation.

B. Applicable Sections in Division 40 – Instrumentation and Control for Process Systems.

C. Division 26 – Electrical.

1.3 ACTION SUBMITTALS / INFORMATIVE SUBMITTALS

A. Submittals shall be provided in accordance with the requirements specified in Section 40 91 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 ADJUSTABLE PRESSURE SWITCH

A. Manufacturers: Shall be United Electric, Ashcroft Series L/Series B, or equal.

B. Performance / Design Critieria:

1. Adjustable pressure switches shall be diaphragm-actuated, dual adjustment pressure switches with SPDT contacts rated for a minimum of 5 Amps at 120 VAC.

2. The dead band shall be adjustable up to 60 percent of full scale. Set points shall fall between 20 and 80 percent of the adjustable range.

C. Materials / Components:

1. The diaphragm and lower housing materials shall be in accordance with the manufacturer's recommendation for the intended service and installation application and as indicated in the data sheet.

2. The process connection size shall be as indicated in the data sheet.

PART 3 -- EXECUTION

3.1 FIELD QUALITY CONTROL

A. Pressure detection systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with Section 40 91 00 Process Control and Instrumentation Systems. Manufacturer's service, supervision, and training shall also be in accordance with Section 40 91 00 Process Control and Instrumentation Systems.

END OF SECTION

SECTION 40 91 12
PROCESS ANALYZER MEASURING SYSTEMS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall furnish and install all process analyzer measuring systems, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 91 00 – Process Control and Instrumentation Systems apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. **General:** The CONTRACTOR shall furnish submittals in accordance with Section 40 91 00 – Process Control and Instrumentation Systems.

1.3 QUALITY ASSURANCE

A. **General:** The accuracy of each instrumentation system or loop shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

1.4 MANUFACTURER'S REPRESENTATIVE SERVICES

A. **General:** Manufacturers representative services shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

1.5 PRODUCT HANDLING

A. **General:** Product handling shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

1.6 GUARANTEE

A. **General:** Guarantees shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Signal Output:** Analyzers shall be "smart" type and shall support remote configuration and calibration. Analyzers shall be interfaced to the plant control system using current regulated 4-20 mA HART protocol (driving 0 to 600 ohms) or Ethernet connection. The Contractor shall perform a complete configuration check of each transmitter prior to site installation.

B. **Power Input:** The analyzer shall be fully isolated 4-wire type with power supply of 120 volts plus and minus 10 percent, 60 Hz plus and minus 5 percent.

C. **Ambient Conditions:** Analyzers shall be suitable for continuous automatic on-line analysis of the indicated parameters under the conditions indicated.

1. Equipment shall operate satisfactorily in ambient temperatures between 0 degrees and plus 132 degrees F or shall be provided with isothermal enclosures so that accuracies will not exceed one percent of span.

2. Process fluid temperatures will range between 32- and 120-degrees F unless indicated otherwise.

D. **Sample Flow:** Flow to non-inline analyzers (generally wet panel-mounted) shall be monitored by a thermal or integral flow switch. Detected loss of flow shall result in generation of control system process alarm. Samples shall not pass-through housings containing electronics unless specifically indicated otherwise.

E. **Local Indication:** Each analyzer shall be provided with local indicator scaled to match the indicated process units (refer to Section 40 91 00 Appendix A – Instrument List).

F. **Calibration:** HART transmitters shall be scaled and configured using the appropriate smart calibration device. Standard 4-20mA analyzers shall be fitted with calibration connections at the analyzer as required by the manufacturer.

G. **Single manufacturer:** All electrodes, fittings, and transmitters on analyzers measuring the same parameter shall be products of a single manufacturer.

2.2 LOW RANGE TURBIDITY MEASURING SYSTEMS

A. Instrument for continuous, online monitoring of turbidity in water that includes predictive diagnostics capability to monitor instrument status. The sensor is used with a controller to measure low range turbidity in water. These sensors collect scattered light at an angle of 90° in a 360° radius around the axis of the incident light beam

B. System Description

a. Measuring range

1) 0 to 700 NTU / FNU / TE/F / FTU

b. Detection Limit

1) 0.0001 NTU / NTU / FNU / TE/F / FTU

c. Accuracy

1) ±2% of reading ±0.01 NTU from 0 to 40 NTU based on formazin primary standard at 25°C

2) ±10% of reading from 40 to 1000 NTU based on formazin primary standard at 25°C

d. Repeatability

1) ±1% of reading or 0.0006 NTU, whichever is greater based on formazin primary standard at 25°C

e. Resolution

1) 0.0001 NTU / FNU / TE/F / FTU / EBC

f. Response Time

1) T90 <30s at 100 mL/min

g. Sample Flow

1) 100 to 1000 mL/min; optimal flow rate 200 to 500mL/min

h. Sample Pressure

1) Max. 6 bar (87 psi) compared to air at sample temperature range of 0 to 40 °C (32 to 104 °F)

2) Max. 3 bar (43 psi) compared to air at temperature range of 40 °C to 60°C (104 °F to 140 °F)

i. Sample Temperature

1) 2 to 60 °C (36 to 140 °F)

C. Certifications

1. CE Compliant

2. US FDA accession number: 1420493-001 EPA version, 1420492-001 ISO version. Complies with IEC/EN 60825-1 and to 21 CFR 1040.10 in accordance with Laser Notice No. 50)

D. Environmental Requirements

1. Operational Criteria

a. Storage Temperature: -40 to 60 °C (-40 to 140 °F)

b. Operating Temperature: 0 to 50 °C (32 to 122 °F)

c. Relative Humidity: 5 to 95 %, non-condensing

E. Warranty

1. The product shall include a one-year manufacturer's warranty from the date of shipment

F. Maintenance Service

1. Per manufacturer's operation and maintenance manual

G. Sensor

1. The low range online laser turbidimeter shall consist of a Class 1 650nm (EPA) or 850 nm (ISO) laser light source and 360° x 90° detection system with predictive diagnostics designed to continuously monitor turbidity in a sample stream. Automatic cleaning and flow measurement options shall be included.

H. Equipment

1. Online turbidimeter

a. Utilizes a laser-based 360° x 90° optical system that measures turbidity from multiple different angles.

b. Continuous particle removal using a vortex created by the fluid path.

c. Includes capability to actively monitor all internal components and present diagnostics on the overall health of the turbidimeter and time to next required maintenance.

d. When connected to a predictive diagnostics capable controller the overall status of instrument performance is displayed as a percentage value via a measurement indicator

e. When connected to a predictive diagnostics capable controller the overall time remaining until maintenance tasks are due is displayed in days

f. Built in-help screens included.

I. Controller

1. Provide a controller transmitter for turbidimeter operation including Ethernet I/P communication option. A single controller may be used for multiple analyzer signals.

J. Calibration Standards

1. Frequency of use of calibration standards determined by recommendation of local regulator.

2. Manufacturer must make available certified calibration standards that can be used in online and bench top instruments for highest calibration accuracy

3. Calibration standards must be capable of being used to calibrate laboratory turbidimeters with similar optics systems.

4. Calibration standards must be capable of functioning with the instrument's optional RFID module.

K. Components

1. Analytical instrument including automatic cleaning module, bubble trap, turbidimeter maintenance kit, glass calibration/verification rod, StablCal® Sealed Vial Calibration Standards. Flow sensor offers real-time information about sample flow into the sensor. Automatic cleaning module reduces operational risk by automating instrument cleaning process.

2. Mounting bracket

3. Desiccant cartridge

4. User Manual

5. Controller Transmitter - Transmitter housing shall be rated NEMA 4X suitable for wall, handrail or panel mounting. Transmitter and sensor shall be from the same manufacturer. Refer to Appendix A of Section 40 91 00 for the complete instrument schedule.

L. Dimensions: Refer to manufacturer's turbidimeter drawings

M. Installation

1. Contractor shall install the analyzer in strict accordance with the manufacturer's instructions and recommendation.

N. Manufacturer's Service and Start-Up

1. Contractor will include the manufacturer's services to perform start-up on instrument to include basic operational training and certification of performance of the instrument.

2. Contractor will include a manufacturer's Service Agreement that covers all the manufacturer's recommended preventative maintenance, regularly scheduled calibration and any necessary repairs beginning from the time of equipment startup through to end user acceptance / plant turnover and the first 12 months of end-user operation post turnover.

3. Items A and B are to be performed by manufacturer's factory-trained service personnel. Field service and factory repair by personnel not employed by the manufacturer is not allowed.

4. Use of manufacturer's service parts and reagents is required. Third-party parts and reagents are not approved for use.

5. Turbidimeter shall be as manufactured by:

   a. Hach TU5400sc Ultra-Low Range Laser Turbidimeter with SC4500 transmitter

   b. Or Equal.

2.3 COLORIMETRIC FREE CHLORINE RESIDUAL MEASURING SYSTEM

A. Online chlorine analyzer for continuous monitoring of free residual chlorine in water. The method of measuring free or total chlorine will be colorimetric. Instrument chemistry will employ N, N-diethyl-p-phenylenediamine (DPD) method.

B. System Description

1. Measurement range:

a. 0 to 10 mg/L (ppm) free residual chlorine

2. Accuracy

a. ± 5% of reading or ±0.04 mg/L (ppm), whichever is greater from 0 to 5 mg/L as Cl2; +/- 10% from 5 to 10 mg/L as Cl2

3. Precision

a. 5% of reading or 0.01 mg/L (ppm), whichever is greater

4. Lower Limit of Detection (LOD)

a. 0.03 mg/L (ppm)

5. Resolution

a. 0.01 mg/L (ppm)

6. Repeatability

a. 5% of reading or 0.01 mg/L (ppm), whichever is greater

7. Cycle Time

a. 2.5 minutes

C. Certifications

1. Complies with US EPA 40 CFR 141.74

2. CE compliant for conducted and radiated emissions CISPR 11 (Class A limits), EMC Immunity EN 61326-1 (Industrial limits), and EN 50581

3. North America: FCC Supplier's Declaration of Conformance, IEC/EN 60529, ICES-003

D. Environmental Requirements

1. Operational Criteria

a. Sample flow rate

1) 60 to 200 mL/minute through the analyzer

b. Sample Filtration

1) Y-strainer with 40-mesh screen or higher

c. Inlet Pressure

1) 4.5 to 75 psig (0.3 to 5.2 bar) supplied to Y-strainer; 1.5 to 5 psig (0.1 to 0.3 bar) supplied to analyzer

d. Sample temperature

1) 41 to 104 °F (5 to 40 °C)

e. Operating temperature

1) 41 to 104 °F (5 to 40 °C)

f. Operating humidity

1) 0 to 90% non-condensing relative humidity

E. Warranty

1. The product shall include a one-year manufacturer's warranty from the date of shipment

F. Maintenance Service

1. Per manufacturer's operation and maintenance manual

G. Equipment

1. Online Chlorine Analyzer

a. Housed in an IP66-rated enclosure.

b. Capable of measuring free residual chlorine by changing the tubing and indicator and buffer solutions.

c. Measurements are taken every 2.5 minutes and results are displayed on a controller display or web-enabled display in the range of 0 to 10 mg/L.

d. Utilizes a built-in flow meter.

e. Real-time flow rate is measured when sample is flowing through the analyzer and results are displayed on a controller display or web-enabled display in mL / min.

f. Connects to a standard controller, which controls and provides power to the analyzer.

g. Performs a blank reference measurement check between analysis points to compensate for sample color, turbidity, and changes in light intensity due to voltage fluctuations or light source aging.

h. Operates with an LED light source at a peak wavelength of 510nm.

i. Capable of operating unattended for 30 days between chemical reagent changes and measurement cell cleaning.

j. Utilizes a three-color status light to indicate operating status.

k. Utilizes three measurement cycle indicator lights to display the phase of the measurement cycle being performed.

l. Has a colorimeter measurement cell window for viewing sample inside cell.

m. Provides step-by-step, on-screen instructions for all routine maintenance activities, including reagent changes, tubing changes, and cell cleanings.

H. Controller

1. Provide a controller transmitter for chlorine analyzer operation including Ethernet I/P communication option. A single controller may be used for multiple analyzer signals.

I. Components

1. Standard Equipment

a. Online chlorine analyzer with standpipe installation kit, cell cleaning kit, and calibration verification kit

b. Installation kit

c. Tubing kit

d. User manual

J. Dimensions: Refer to manufacturer's turbidimeter drawings

K. Installation

1. Contractor shall install the analyzer in strict accordance with the manufacturer's instructions and recommendation.

L. Manufacturer's Service and Start-Up

1. Contractor will include the manufacturer's services to perform start-up on instrument to include basic operational training and certification of performance of the instrument.

2. Contractor will include a manufacturer's Service Agreement that covers all the manufacturer's recommended preventative maintenance, regularly scheduled

calibration and any necessary repairs beginning from the time of equipment startup through to end user acceptance / plant turnover and the first 12 months of end-user operation post turnover.

3. Items A and B are to be performed by manufacturer's factory-trained service personnel. Field service and factory repair by personnel not employed by the manufacturer is not allowed.

4. Use of manufacturer's service parts and reagents is required. Third-party parts and reagents are not approved for use.

5. The colorimetric chlorine residual analysis system shall be as manufactured by:

a. Hach CL17sc Colorimetric Chlorine Analyzer with SC4500 transmitter

1) Free Chlorine: Analyzer kit 8572700 with free chlorine reagents

b. Or Equal.

M. General

1. Analysis Systems shall be furnished complete with a one-year supply of spare membrane assemblies, sensor electrolyte (as applicable), active/inactive reagents (as applicable), pre-conditioning filters and maintenance kit. Transmitter and sensor shall be of the same manufacturer. Refer to Section 40 91 00 Appendices for the complete instrument schedule.

PART 3 -- EXECUTION

3.1 GENERAL

A. Electrical interface and code compliance shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

3.2 CALIBRATION

A. The calibration of all devices shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

3.3 INSTALLATION

A. The installation of all devices shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

3.4 LOOP TESTING

A. The loop testing of all devices shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

3.5 PRE-COMMISSIONING

A. The pre-commissioning of all devices shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

3.6 ON-SITE SUPERVISION

A. The on-site supervision of all devices shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

3.7 PERFORMANCE TESTING

A. The performance testing of all devices shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems

3.8 RECORD DRAWINGS

A. Record Drawings shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

3.9 TRAINING

A. Training for all equipment and software shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

3.10 ACCEPTANCE

A. All acceptance testing shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

- END OF SECTION -

SECTION 40 92 00
CONTROL PANELS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide control panels, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 91 00 - Process Control and Instrumentation Systems apply to this Section.

C. The provisions of this Section apply to Section 40 92 01 - Control Panel Instrumentation except where indicated otherwise.

D. The provisions of this Section apply to local panels provided in equipment systems specified in other sections unless indicated otherwise in those sections.

E. The requirements of Division 26 specifications shall apply to this section.

1.2 CONTRACTOR SUBMITTALS

A. **General:** Submittals shall be furnished in accordance with Section 01 33 20 – Submittal Procedures.

B. **Control Panel Engineering Submittal:** The CONTRACTOR shall submit a control panel engineering submittal (CPES) for each control panel furnished. The CPES shall completely define and document the construction, finish, layout, power circuits, signal and safety grounding circuits, fuses, circuit breakers, signal circuits, internally mounted instrumentation and SCADA system components, face plate mounted instrumentation components, internal panel arrangements, and external panel arrangements. All panel drawings shall, as a minimum, be "B" size with all data sheets and manufacturer specification sheets being "A" size. The submittal shall be in conformance with ISA-S20 - Standard Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves, shall be submitted as a singular complete bound volume or multi-volume package within 120 calendar days after Notice to Proceed, and shall have the following contents:

1. A complete index shall appear in the front of each bound volume. Drawings and data sheets associated with a panel shall be grouped together with the panels being indexed by systems or process areas. Panel tagging and nameplate nomenclature shall be consistent with the requirements of the contract requirements.

2. Scale construction drawings which define and quantify the type and gauge of steel to be used for panel fabrication, the ASTM grade to be used for structural shapes and straps, panel door locks and hinge mechanisms, type of bolts and bolt locations for section joining and anchoring, details and proposed locations for "UNISTRUT" members, stiffener materials and locations, electrical terminal box and outlet locations, electrical

access locations, print pocket locations, writing board locations, and lifting lug material and locations.

3. Scaled physical arrangement drawings drawn to scale which define and quantify the physical groupings comprising control panel sections, auxiliary panels, subpanels, and racks. Cutout locations with nameplate identifications shall be shown.

4. Front of panel layouts for all control panels.

5. Schematic/elementary diagrams shall depict all control devices and circuits and their functions.

6. Wiring/connection diagrams shall locate and identify electrical devices, terminals, and interconnecting wiring. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all electrical and control devices.

7. Interconnection diagrams shall locate and identify all external connections between the control panel/control panel devices and associated equipment. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all panel ingress and egress points.

8. Control sequence diagrams to portray the contact positions or connections required to be made for each successive step of the control action. Written descriptions explaining the control sequence diagrams and system operation shall be furnished.

9. Completed ISA S20 data sheets for all instrumentation devices associated with each control panel supplemented with manufacturer specification sheets which verify conformance to the requirements of the Contract Documents

10. A bill of materials which enumerates all devices associated with the control panel.

11. A priced listing of analog spare parts in conformance with Section 40 91 00 - Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Environmental Suitability:** Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated by the CONTRACTOR. Heating, cooling, and dehumidifying devices shall be provided in order to maintain all instrumentation devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The CONTRACTOR shall provide all power wiring for these devices. Enclosures suitable for the environment shall be provided. Instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

B. Control panel power shall be 120 VAC. Where the electrical power supply to the control panel is 240 VAC single phase or 480 VAC 3-phase, the control panel shall be provided with a control panel transformer. Control conductors shall be provided in accordance with the indicated requirements.

C. The control panel shall be the source of power for any 120 VAC solenoid valves interconnected with the control panel. Equipment associated with the control panel shall be ready for service after connection of conductors to equipment, controls, and control panel.

D. The main feeder disconnect shall have a door-mounted handle unless otherwise indicated.

E. Unless indicated otherwise, control panels shall be housed in NEMA rated enclosures. Control panels shall be either freestanding, pedestal-mounted or equipment skid-mounted, as indicated. Internal control components shall be mounted on an internal back-panel or side-panel as required.

F. Each source of foreign voltage shall be isolated by providing disconnecting or pull-apart terminal blocks or a disconnect operable from the control panel front. Each control panel shall be provided with identified terminal strips for the connection of all external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use.

G. Motor starters, where required, shall be furnished, installed, and configured by others (reference Section 40 90 10 for CONTRACTOR system communication requirements). Each motor starter shall be provided with contact closures for motor overload, local indication, and remote alarm. Electrical components shall be of standard American manufacture.

H. Discrete inputs to the control panel shall be 24Vdc. Discrete outputs from the control panel shall be provided by electrically isolated contacts rated for 5 amps at 120 VAC. Analog inputs and outputs shall be isolated 4-20 mA, 2-wire signals with power supply.

I. Control panel mounted devices shall be mounted a minimum of 42-inches above finished floor elevation.

J. Panels shall be assembled in accordance with published UL-508 standards and shall prominently bear the UL-508 label as well as the applicable NEMA rating label after final assembly.

2.2 CONTROL PANELS

A. Materials

1. Panel section faces shall be No. 10 gauge minimum thickness for free standing panels and No. 14 gauge minimum thickness for wall mounted or pedestal mounted panels. Materials shall be selected for levelness and smoothness.

2. Relay rack high density type panels shall utilize standard relay racks with No. 14 gauge steel frame and supports.

3. Structural shapes and strap steel shall comply with ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates, Grade C.

    a. Bolting Material: Commercial quality carbon steel bolts, nuts, and washers shall be 1/2-inch diameter with UNC threads. Carriage bolts shall be used for attaching end plates. All other bolts shall be hex end machine bolts. Nuts shall be hot pressed hex, American Standard, heavy. Standard wrought washers shall be used for foundation bolts and attachments to building structures. Other bolted joints shall have SAE standard lock washers.

4. Construction: Dimensions shall be in accordance with vendor's requirements. Elevations and horizontal spacing shall be subject to Engineer's approval.

B. Fabrication

1. End plates, top plates, and top closure panels (to hung ceiling) shall be provided when required by the material requisition. End plates, top plates, and top closure panels shall be removable with countersunk bolts to match panels. Top closure panels shall be furnished in lengths which match the widths of standard panels, except that one top closure panel may extend across two 4-foot 6-inch wide or five 2-foot-wide standard panels. The vertical joints of these panels shall align with the vertical joints of the standard panels.

2. End closure or rear closure doors shall be provided where required. Such doors shall be flush fitting, gasketed, and be of the hinged lift-off type with lockable door handles. A common key shall be provided for all doors on one panel assembly. Removable access panels shall be provided with dished handle fasteners. Screw driver 1/4 turn or Dzus type fasteners are not acceptable.

    a. The flanged edges of all panels shall be straight and smooth. Corners shall be welded and ground smooth.

    b. The face of the panel shall be true and level after flanging.

    c. All panel cutouts and holes may be cut or drilled by any standard method that does not cause deformation. Burrs shall be ground smooth.

    d. Adjacent panels shall assemble with faces flush. Gaps or cracks shall not be visible from the front of the assembled instrument board.

    e. Stiffeners shall be welded to the back of panels, as required to prevent panel deformation due to the weight of face mounted instruments.

    f. Panels shall be self-supporting as defined below.

C. Framework and Supports

1. The rear of each panel section shall have a steel framework assembled to it for supporting conduit, wireways, switches, piping, and instrument accessory items such as relay or terminal enclosures, transducers, pressure switches, valves, and air relays. The

main framework shall be constructed of standard structural shapes. Special shapes such as "**Unistrut**" may be used for secondary supports. Framework must neither interfere with instrument connections nor interfere with access needed for maintenance or adjustments.

2. Steel framework shall extend 2-feet 4-inches back from the panel face or as indicated in the material requisition. Where indicated, individual adjustable leg supports shall be provided at the back of the framework so that the entire panel is self-supporting.

D. Preparation of Panel Surface

1. The following requirements apply to the front and rear face of the panel, both sides and the edges of all flanges, and the periphery of all holes or cutouts.

   a. High spots, burrs, and rough spots shall be ground smooth.

   b. The surfaces shall be sanded or sandblasted to a smooth, clean, bright finish.

   c. All traces of oil shall be removed with a solvent.

   d. The first coat of primer shall be applied immediately.

E. Panel Finishing

1. A Thin coat primer surface shall be applied over the entire panel surface.

2. Wet sand, dry, then quick glaze spot putty on the front of the panel only. Dry, then wet sand again and dry

3. A primer surface shall be applied on the front of the panel only.

4. Wet sand to smooth clear finish, then dry.

5. At least 2 coats of air-dry, satin finish lacquer enamel shall be applied over the entire surface. Color to be as approved by Engineer.

6. CONTRACTOR shall supply 2 one-pint containers of air drying, matching paint for field touch-up of the panel face.

F. **Instrument Finishing:** The final coats applied to painted surface of instrument cases, doors, or bezels which are visible from the front of panels shall be manufacturer's standard unless otherwise indicated. Black japan or "crinkle" finishes on instrument cases are not acceptable.

G. Mounting of Instruments

1. The panel vendor shall provide cutouts and shall mount all instrument items indicated to be panel mounted, including any instruments indicated to be furnished by other vendors but installed in the panel.

2. The panel vendor shall also mount behind the panels other instrument accessory items as required for functionality as indicated.

3. Equipment mounted at the rear of panel shall be installed to allow for commissioning adjustments, servicing requirements, and cover removal.

4. Spare space shall be kept clear of wiring, etc., to give maximum space for future additions.

H. Electrical Requirements

1. The CONTRACTOR shall provide conduit, wireways, switches, wire, and electrical fittings for 120-volt circuits to instruments and other electrical devices as required for a complete and operable installation.

2. Conduit, wireways, junction boxes and fittings shall be provided for signal wire, thermocouple, or resistance thermometer lead wire. Conduit or wireway runs shall include those required between temperature sensors and temperature transmitters and between the thermocouple wireway or junction box and instruments.

3. Each terminal connection shall have a plastic plate with a terminal and instrument tag number. Wiring shall be identified with stamped tubular wire end markers.

4. Freestanding panels shall be provided with switched 100-watt incandescent back-of-panel lights. One light shall be provided for every 4-feet of panel width and shall be mounted inside and in the top of the back-of-panel area.

5. Freestanding panels shall be provided with a 15-amp, 120 volt, service outlet circuit within the back-of-panel area. The circuit shall be provided with 3 wire, 120 volt, 15 ampere, duplex receptacles, one for every 4-feet of panel width (one minimum per panel), spaced evenly along the back-of-panel area.

6. Wall mounted or pedestal mounted panels shall be so sized as to adequately dissipate heat generated by equipment mounted in or on the panel.

7. Wall mounted or pedestal mounted panels mounted outside or in unshaded areas shall be provided with thermostatically controlled heaters that maintain inside temperature above 40 degrees F.

8. Provide a hand switch controlled 100-watt incandescent light and a breaker protected 120 volt, 15 amp duplex receptacle within each wall mounted or pedestal mounted panel larger than 4 cubic feet volume.

9. Wiring Methods: Wiring methods and materials for all panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise indicated.

10. Signal and Control Circuit Wiring

    a. Wire type and sizes: Conductor shall be flexible stranded copper machine tool wire, UL listed Type MTW, and shall be rated 600 volts. Wires for instrument signal

circuits and alarm input circuits shall be No. 14 AWG. All other wires, including shielded cables, shall be No. 16 AWG minimum.

b. Wire Insulation Colors: Conductors supplying 120 VAC power on the line side of a disconnecting switch shall have a black insulation for the ungrounded conductor. Grounded circuit conductors shall have white insulation. Insulation for ungrounded 120V AC control circuit conductors shall be red. Wires energized by a voltage source external to the control panel shall have yellow insulation. Insulation for DC conductors shall be blue.

c. Wire Marking: Wire numbers shall be marked using white numbered wire markers made from plastic-coated cloth, **Brady Type B-500** or equal, or shall be heat shrink plastic.

d. Flexible conduit is not acceptable except when specifically approved by the Engineer in writing.

e. Conduit fittings shall be **Crouse Hinds** cast fittings or equal.

f. For case grounding, panels shall be provided with a 1/4-inch by 1-inch copper ground bus complete with solderless connector for one No. 4 AWG bare stranded copper cable. The copper cable shall be provided by the CONTRACTOR and shall be connected to a system ground loop.

11. Communication Cables

    a. All Ethernet cables shall be CAT 6 minimum.

12. Electrical Locations

    a. When the Contract Documents call for thermocouple actuated instruments, the thermocouple lead wire shall be installed without junction by the CONTRACTOR. The panel vendor shall provide dedicated empty conduits or wireways running from the instrument(s) to the top or bottom of the panel as called for in the material specifications or as otherwise required. Sizing of the conduit or wireway shall be in accordance with the capacity of the instrument(s).

    b. Single case (no remote logic) annunciator units shall be installed at the top of panel and may be considered as a terminal box when top of panel wire entry is indicated. If bottom of panel entry is indicated, a terminal box shall be provided at the bottom of the panel and be wired to the annunciator unit. Terminals shall be identified with plastic marker strips.

    c. Terminal boxes for incoming and outgoing signal leads shall be located at the top or bottom of the panel as indicated in the material specification, or as otherwise required.

13. Power Supply Wiring

a. Unless otherwise indicated, instruments, alarm systems, and motor controls shall operate on 120-volt, 60 Hz circuits.

b. At a location near the top of the panel (or bottom), the panel fabricator shall provide terminal box connections for the main power supply entry.

c. Power supply switches for alarm units shall be 3 pole type, arranged to open both power circuits and alarm circuits. Each annunciator unit shall be equipped with a separate switch.

d. Instruments located on the same panel section and serving the same process unit may be connected to a common branch circuit from the power supply. The number of circuits depends on the circuit load as noted herein. A 15 amp, 2 pole circuit breaker shall be provided in each branch circuit. The circuit load shall not exceed 10 amp. Different panel sections or different process units must not use common branch circuits. When instruments do not come equipped with integral fuses, provide fuses as required for the protection of individual instruments against fault currents. Fuses shall be dinrail-mounted on the panel backplane in a fuse terminal block with each fuse identified by a service name tag. Fuses shall be as manufactured by **Weidmuller SAK Series KDKS** or equal.

e. Each potentiometer type instrument, electronic transducer, controller, or analyzer shall have an individual disconnect switch. Disconnect switches shall have metal or plastic tags indicating instrument tag numbers. Individual plug and cord set power supply connections may be used without switches when indicated in the material specification.

f. Where alarm units are single unit types, one switch may be used to disconnect not more than 6 alarm units located on the same or adjacent panels.

14. Alarm Wiring: The panel vendor shall install and wire alarms including light cabinets, audible signal units, test and acknowledge switches, and remote logic units as indicated. Interconnecting wiring to panel mounted initiating devices shall also be wired by the panel vendor. The wiring from external initiating devices shall be provided by the CONTRACTOR. Where plug and cord sets are provided for component interconnection, the panel vendor shall harness and support the cables in neat and orderly fashion. Where separate wire is required, panel vendor shall install No. 16 AWG with THWN or THHN insulation between all components.

15. Signal Wiring

    a. Signal Wire - Non-Computer Use

        1) Signal wire shall be twisted pair or triads in conduit or troughs. Cable shall be constructed of No. 16 AWG copper signal wires with THWN or THHN insulation.

        2) Color code for instrument signal wiring shall be as follows:

            Positive (+) – Black

Negative (-) - White

3) Multiconductor cables where indicated shall consist of No. 16 AWG copper signal wires twisted in pairs, with 90-C, 600 V fault insulation. A copper drain wire shall be provided for the bundle with a wrap of aluminum polyester shield. The overall bundle jacket shall be PVC.

b. Signal Wire - Computer Use

1) Signal wires shall be similar to those for non-computer use but each pair shall be triplexed with a copper drain wire and aluminum polyester tape shall be applied over the triplexed group. Cable shields, including thermocouple extension leads shall be terminated in the central control room at the computer system grounding bus. Continuity of the shield shall be maintained throughout the cable runs.

c. Multi-conductor cables, wireways and conduit shall be sized to allow for 10 percent spare signal wire.

I. **Labor and Workmanship:** Panels shall be fabricated, piped, and wired by fully qualified workers who are properly trained, experienced, and supervised.

2.3 SCADA SYSTEM ENCLOSURES

A. Each SCADA system PLC and remote I/O system and corresponding housing, I/O modules, power supply modules, communication interface devices, and peripheral equipment shall be mounted inside a steel NEMA 12 enclosure (for indoor installation within controlled environments), complete with 3-point latch and interior lighting kit. Process area or sheltered outdoor panels shall be 316 stainless steel NEMA 4X panels with 3-point latching handle (Hoffman Powerglide), heating strip, interior lighting kit, corrosion inhibitor and recirculation fans (strategically located to cool critical components). Outdoor exposed mounted panels shall be similarly configured with the addition of 316 stainless steel sunshields on all sides.

B. All PLC and remote IO cabinets shall also include the following components, wired to the panel I/O for control system monitoring:

1. 24Vdc primary and secondary power supply status monitoring (as shown on the I/O list).

2. Controller webpage monitoring (as applicable)

C. For all panels, I/O wiring from the field to the remote I/O system shall be terminated on terminal blocks in the lower portion of the enclosure. Sufficient terminal blocks shall be provided to accommodate the full I/O compliment of the furnished I/O racks. A nameplate shall be mounted on the outside of the door of the enclosure and be engraved with "XX-PLC-XXXX" or "XX-RIO-XXXX" where "X" is the number or description as shown on the contract drawings. (Nameplates shall be as detailed in Specification 26 00 00.)

D. Dimensions shown on the contract panel elevation drawings are provided as reference only. Final enclosure dimensions shall be as established by the CONTRACTOR to accommodate all components required plus spare. Enclosures shall be as manufactured by **Hoffman**, or equal.

E. All panels furnished shall adhere to the requirements of NEC article 409 (SCCR).

2.4 SPARE PARTS AND SPECIAL TOOLS

A. In Control panel spare parts selected by the ENGINEER and special tools shall be furnished in accordance with Section 40 91 00 - Process Control and Instrumentation Systems.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Preparation for Shipment and Shipping

1. Panels shall be crated for shipment using a heavy framework and skids. Panel sections shall be cushioned to protect the finish of the instruments and panel during shipment. Instruments which are shipped with the panel shall further have suitable shipping stops and cushioning material installed to protect parts which could be damaged due to mechanical shock. Each separate panel unit shall be provided with removable lifting lugs to facilitate handling.

2. Shipments shall be by air ride van unless otherwise indicated.

3. Control panel testing and inspection shall be performed prior to shipping.

4. Control panels shall be installed in accordance with Section 40 91 00 - Process Control and Instrumentation Systems.

3.2 CONTROL PANEL SIGNAL AND CONTROL CIRCUIT WIRING

A. **Wiring Installation:** Wires shall be run in plastic wireways except (1) field wiring, (2) wiring between mating blocks in adjacent sections, (3) wiring from components on a swing out panel to components on a part of the fixed structure, and (4) wiring to panel mounted components. Wiring run from components on a swing out panel to other components on a fixed panel shall be made up in tied bundles. These bundles shall be tied with nylon wire ties and shall be secured to panels at both sides of the "hinge loop" so that conductors are not strained at the terminals.

B. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and be secured to the inside face of the panel using adhesive mounts.

C. Wiring to rear terminals on panel-mount instruments shall be in plastic wireways secured to horizontal brackets above or below the instruments in about the same plane as the rear of the instruments.

D. Shop Drawings shall show conformance to the above wiring installation requirements.

E. **Wire Marking:** Each signal, control, alarm, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number which shall be shown on Shop Drawings. These numbers shall be marked on conductors at every terminal. Wire labels shall be generated by a portable label printer with self-adhesive labels. Label printer shall be as manufactured by **Brady, BMP41 Model** or equal.

3.3 CALIBRATION, TESTING, AND INSTRUCTION

A. **General:** Calibration, testing, and instruction shall be performed in accordance with Section 40 91 00 - Process Control and Instrumentation Systems.

- END OF SECTION -

SECTION 40 92 01
CONTROL PANEL INSTRUMENTATION

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide control panel instrumentation, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 91 00 - Process Control and Instrumentation Systems apply to the WORK of this Section.

C. The requirements of Section 40 92 00 - Control Panels apply to the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be included within the submittals of Section 40 92 00 - Control Panels.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Power Supplies:** Power supplies shall conform to the requirements of Section 40 91 00 - Process Control and Instrumentation Systems.

2.2 INDICATORS (NOT USED)

A. RECORDERS (NOT USED)

2.3 CONTROLLERS AND CONTROL STATIONS (NOT USED)

2.4 INTEGRATORS AND TOTALIZERS (NOT USED)

2.5 FUNCTION MODULES

A. **Signal Splitters**: (NOT USED)

2.6 CONVERTERS

A. **Current-to-current converter/isolators**: (NOT USED)

2.7 TRANSMITTERS

A. **Current Transmitters:** Not used

2.8 ADDITIONAL PANEL COMPONENTS

A. Panel-mounted devices, conductors, and other panel electrical components shall be furnished in accordance with Division 26 specifications. Panel-mounted devices shall be mounted a minimum of 40-inches above finished floor elevation.

B. If used, pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30 mm. Miniature style devices are not acceptable. Devices shall be as manufactured by **General Electric, Eaton Electrical,** or equal.

1. Lens colors shall be consistent with the OWNER's current standard.

2. Pilot lights shall be low voltage, transformer, push-to-test type.

3. Provide hazardous location type pilot devices in classified locations.

4. Lever-type switches shall be furnished as indicated on the P&ID panel elevation drawings.

C. Relays shall be 3 PDT with 10-amp contacts, plug-in type utilizing rectangular blades and provided with sockets for screw-type termination and hold-down clips. Relays shall be as manufactured by **Square D, Idec** or equal.

D. Terminal strips shall be provided for all panels and shall be the flanged fork or ring lug type suitable for No. 12 AWG stranded wire minimum. Provide 25 percent spare terminals in each panel.

E. Time delay relays shall be combination on delay and off delay (selectable) with adjustable timing ranges. Provide socket with screw terminal connections and retaining strap. Time delay relays shall be as manufactured by **ATC, Phoenix Contact** or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Control panel instrumentation shall be executed in accordance with Section 40 91 00 – Process Control and Instrumentation Systems.

- END OF SECTION -

SECTION 40 95 10
PLC BASED CONTROL SYSTEMS HARDWARE

PART 1 — GENERAL

1.1 THE REQUIREMENT

A. Herein, the term CONTRACTOR shall be used to represent the party responsible to the GENERAL CONTRACTOR for the Work of this division.

B. The CONTRACTOR shall furnish, supervise installation, assemble, and configure, program, and place into service the Magna WRF Secondary Reuse Building PLC-based Control System (PLCS), herein referred to as the Plant PLCS and specified under this Section, Specification Section 40 90 10 – Control Strategies and in Specification Section 40 95 20 - PLC-Based Control Systems Software. All work shall be executed in accordance with the requirements of the Contract Documents. The CONTRACTOR shall also reference the I/O list in Appendix A.

C. **Plant System Integrator**: The CONTRACTOR shall be singularly responsible for selecting, configuring, and verifying correct operation of compatible hardware and software to provide a functional Plant PLCS SYSTEM. The CONTRACTOR shall be the integrator of all hardware and all database, data acquisition, control, display, and all other system software. Additionally, the CONTRACTOR shall be responsible for the application programming of the PLCs and GUI software per Section 40 90 10 – Control Strategies and other sections of the contract specifications.

D. **Vendor Package Supplier:** It is the intent of these specifications to have the Vendor Package Supplier of the filter package systems to be singularly responsible for selecting, configuring, and verifying correct operation of compatible hardware and software to provide a functional Vendor PLCS. To preserve this focused responsibility, the Vendor Package Supplier shall be the integrator of the furnished vendor hardware, database, data acquisition systems, control functions, operator displays and all other system software. Additionally, the Vendor Package Supplier shall be responsible for the application programming of the furnished VPLCS and GUI software per the Vendor submitted / Engineer approved Control Strategies, applicable general and process specific sections of Section 40 90 10 and other sections of the contract specifications.

E. **Plant/Vendor PLCS Configuration:** The PLCS and Vendor PLCS shall consist of PLC's and all required equipment and peripherals as shown on the Network Block Diagrams and as described in these specifications, and as required to meet the functional intent of the specifications. Substitutions for Engineer approved and/or specified functions are not permitted

F. The PLCS and VPLCS shall be in conformance with the following key system criteria:

    a. Both PLCS and Vendor PLCS shall be of the same manufacturer

b. Unless noted otherwise, peer to peer networks shall conform to IEEE 802.3 Ethernet protocols to preserve a nonproprietary system infrastructure.

c. All database structures shall strictly adhere to SQL and promote an open interface with third party software applications

G. **Scope of Work**:

a. The CONTRACTOR shall furnish and install the Plant PLCS as specified within the Contract Documents. The CONTRACTOR shall be responsible for all equipment selection and supply, hardware and software submittal preparation, system integration, programming, graphics generation, supervision of installation, testing, training, start-up, and other implementation activities for the Plant PLCS as detailed in the contract documents. The PLC hardware and software shall be standardized to utilize off-the-shelf, commercially available configurations of hardware and software modules.

b. The CONTRACTOR shall install and field test each vendor PLCS under supervision of the Vendor Package Supplier as specified within the Contract Documents. For each vendor package, the Vendor shall be responsible for all equipment selection and supply, hardware and software submittal preparation, system integration, programming, graphics generation, supervision of installation and field testing, training, start-up, and other implementation activities as detailed in the contract documents. The PLC hardware and software shall be standardized to utilize off-the-shelf, commercially available configurations of hardware and software modules.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS.

A. PLC-based control systems-hardware reference specifications, codes, and standards shall be provided in accordance with Specification Section 40 91 00 - Process Control and Instrumentation Systems.

1.3 SUBMITTALS

A. **General:** Unless specifically noted otherwise, submittal requirements of sub-section 1.3 apply to both Plant PLCS submittals and the individual Vendor package PLCS submittals and shall be in accordance with section 01 33 20 – Submittal Procedures.

B. **Shop Drawings**: Vendor PLCS submittals shall be in accordance with the applicable requirements of Specification Section 40 91 00 - Process Control and Instrumentation Systems. Vendor PLCS submittals shall, however, shall be made separately from other process control and instrumentation system submittals. Both PLCS and Vendor PLCS software submittals shall be provided in accordance with the requirements of Specification Section 40 95 20 - PLC-Based Control Systems-Software

C. **Hardware Submittals:** The PLCS hardware submittal shall be a singular all-inclusive submittal which shall include but not be limited to:

1. A complete index appearing in the front of each bound submittal volume. System groups shall be separated by labeled tags.

2. Complete grounding requirements for the entire PLCS including any requirements for PLCS communication networks and control room equipment.

3. Requirements for physical separation between PLCS components and 120-volt, 480-volt power sources.

4. Data sheets shall be included for each PLCS component together with a technical product brochure or bulletin. These data sheets shall show the component name as used within the Contract Documents, the manufacturer's model number or other identifying product designation, the project tag number, the project system of which it is a part, the project site to which it applies, the input and output characteristics, the requirements for electric power, the ambient operating condition requirements, and details on materials of construction.

5. Complete and detailed bills of materials: A bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for each component of the VPLCS system. Bills of material shall include all items within an enclosure.

6. Site-specific (and Vendor skid) arrangement and construction drawings for all equipment cabinets, and/or consoles including dimensions, identification of all components, preparation and finish data, nameplates, and the like. Drawings shall be scaled and show the position of the equipment at its intended installation location. Drawings must show a scaled representation of the placement of all equipment and its spatial relationship to all other equipment located in the abutting and adjoining areas. All required access and clearances associated with the equipment must be shown with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

4. Complete PLC System calculations to include, but not be limited to:

    a. PLC memory calculations to demonstrate that the specified processor and memory allocation provides 150% of memory requirements.

    b. PLC card calculations to demonstrate that the specified number of installed I/O cards meets present and 20% spare requirements.

    c. PLC I/O chassis sizing and quantity to accommodate I/O and communication cards for present, future and 20% spare requirements.

    d. PLC power supply requirements for each PLC.

5. Calibration, adjustment, and test details for all PLCS and Vendor PLCS components.

D. OWNER’s Manuals: General requirements for OWNER’s Manuals are as described in Specification Section 40 91 00 – Process Control and Instrumentation Systems. The following items shall also be included in the software manual:

1. A documented PLC program listing including the I/O list and housing configuration for each PLC, a memory usage report for each PLC, and a register layout list for each PLC.

2. A documented configuration listing for each Ethernet switch, the Panel PC, and any changes to existing server.

3. Operation and maintenance manuals for the PLCS, Vendor PLCS, Ethernet switches, Panel PC and all other hardware specified herein and shown on the contract drawings.

E. PLCS and Vendor PLCS Test Procedures

1. Procedures shall be prepared for the Reuse Building PLCS by the CONTRACTOR and Vendor Package Supplier, separately. The procedures shall be in narrative form and shall describe sequentially the operational steps to be followed in verifying the correct operation of the system including all features described in the Engineer approved control strategies and any additional control requirement described in Specification Section 40 90 10. All PLC, OIT, or Panel PC equipment that functions together to form a complete package system shall be tested together.

F. Factory Test Procedure:

1. The CONTRACTOR and Filter Vendor Package Supplier shall prepare and submit a factory test procedure which incorporates test sequences, test forms, samples of database lists, a testing block diagram, and an estimated test duration which comply with the requirements of the factory test specified herein. The PLCS and Vendor PLCS shall be tested separately.

1.4 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. Refer to Specification Section 40 91 00 for additional Manufacturer’s services required.

1.5 STORAGE AND HANDLING

A. All equipment and materials delivered to the job site shall be stored in a location which shall not interfere with the operations of the plant’s personnel or interfere with construction. Storage and handling shall be performed in a manner which shall afford maximum protection to the equipment and materials. It is the CONTRACTOR responsibility to assure proper handling and on-site storage.

1.6 SPECIAL WARRANTY REQUIREMENTS

A. Special warranty requirements shall be in accordance with the applicable requirements of Specification Section 40 91 00 and shall be coordinated by the CONTRACTOR. The following additional warranty requirements apply to the entire VPLCS (inclusive of the VPLCS of all Vendor packages listed in Section 40 91 00):

B. Equipment, software, and materials which do not achieve design requirements after installation shall be replaced or modified by the CONTRACTOR to attain compliance. All associated costs shall be the responsibility of the CONTRACTOR. Following replacement or modification, the CONTRACTOR shall retest the system and perform any additional

procedures needed to place the complete VPLCS in satisfactory operation and attain design compliance approval from the Engineer.

C. The CONTRACTOR warrants the materials and workmanship used for the VPLCS control system and further guarantees the materials and workmanship used for any equipment and materials produced and furnished hereunder as a part of the Work to be as herein specified and agreed upon, free from injurious defects, and in all respects satisfactory for the service required.

D. The CONTRACTOR warrants/guarantees the satisfactory performance of the equipment and materials under operating conditions for a period of two years after the date of acceptance of certificate of completion (i.e., completion of all contractual items including a successful system performance test as specified in Part 3 of this section). In the event that tests and inspections disclose latent defects or failure to meet the specified requirements, the CONTRACTOR upon notification by the Engineer shall proceed at once to correct or repair any such defects or non-conformance or to furnish, at the delivery point named in the Contract Documents, such new equipment or parts as may be necessary for conformity to the specified requirements, and shall receive no additional compensation therefore. In the case of any required repairs or other corrective or remedial work covered under warranty, the warranties on all such corrections, repairs, new equipment, or parts shall be extended for an additional 24 months from the date of final acceptance or 12 months from the date of completion of any such corrections, repairs, new equipment, or parts, whichever date is later. The CONTRACTOR shall reimburse the Buyer for all costs incurred in the removal of the defective material and installation of the replacement.

PART 2 — PRODUCTS

2.1 GENERAL

A. The requirements of Specification Section 40 91 00 apply to this Section.

B. All materials and all VPLCS equipment furnished under this Contract shall be new, free from defects, of first quality, and produced by manufacturers regularly engaged in the manufacture of these products.

C. Hardware Commonality: Where there is more than one item of similar equipment being furnished all such similar equipment shall be the product of a singular manufacturer.

D. PLCS Growth Provisions:

1. In addition to satisfying the functional requirements of these specifications, all PLCS equipment and resources including PLC memory requirements GUI software, etc., shall be provided to accommodate a 20 percent expansion in the number of I/O points shown on the drawings and/or listed in the appendix.

2. All equipment and resources, including PLC I/O cards and implementation services, shall be provided such that at least 20 percent project growth (beyond listed future points) can be implemented into the VPLCS without any additional cost to the Buyer. The I/O points included in the 20 percent project growth requirement shall be termed

"implemented spare I/O". The 20 percent implemented spare I/O is 20 percent of the total project I/O listed in Appendix A. After factory testing the unused implemented I/O, if any, shall be delivered to the Owner as spare I/O.

3. The Plant PLCS being furnished shall be capable of being modularly expanded to accommodate a twofold increase in process reporting/display requirements and manual input requirements. This does not apply to the Filter Vendor PLCS

4. All equipment and resources shall be able to modularly accept this anticipated future expansion without the need to replace or retire any PLC component or resource.

2.2 PLC ENCLOSURES

A. Each PLC and its corresponding I/O modules, power supply module(s), communication interface device(s), and peripheral equipment, shall be mounted inside suitable enclosures. All I/O wiring from the field to the I/O modules shall be routed within wireways and terminated on terminal blocks in the enclosure. Fiber optic cabling shall be routed within panel wireways, and all fibers (active and spare) terminated within the specified fiber optic patch panel. Fiber jumper cables shall be labeled and routed within wireways.

B. VPLCS enclosures shall be provided in accordance with Specification Section 40 92 00 - Control Panels.

2.3 HARDWARE

A. **Programmable Logic Controller**:

1. Construction: Each PLC central processing unit (CPU) shall be of solid-state design. All CPU operating logic shall be contained on plug-in modules for quick replacement. Chassis wired logic is not acceptable. The controller shall be capable of operating in a hostile industrial environment (i.e., subject to heat, electrical transients, RFI, vibration, etc.) without fans, air conditioning, or electrical filtering (from 0° to 60° C at 95 percent humidity, non-condensing).

2. Components-General: Each PLC shall have all of the facilities required to implement the control schemes and database shown and specified in the Contract Documents. PLCs shall all have floating point math and PID controller modulating capability. Each CPU shall provide internal fault analysis with a fail-safe mode and a dry contact output for remote location alarming, and a local indicator on the PLC frame in the event of a fault in the PLC.

3. Central Processors: Each central processor shall contain all the relays, timers, counters, number storage registers, shift registers, sequences, arithmetic capability, and comparators necessary to perform the specified control functions. It shall be capable of interfacing sufficient discrete inputs, analog inputs, discrete outputs, and analog outputs to meet the specified requirements plus at least 100 percent excess capacity. All PLCS shall be provided to support and implement closed loop floating and PID control which is directly integrated into the PLC control program. The power supply shall contain capacitors to provide for orderly shutdown in the event that incoming power does not meet specifications. If this occurs, the processor will cease operation,

forcing all outputs off. The processor shall have a key type memory protect switch to prevent unauthorized program changes. The processor shall include floating point hardware.

4. Memory: Each programmable controller shall be supported by CMOS semiconductor memory with battery backup. (The CMOS user programming memory shall be as defined under paragraph 2.3.A-8.) The unit shall also be equipped with nonvolatile flash memory of sufficient capacity to store the fully commented control program, tag data, and unit operating system with room for 50% growth. An indicator shall show the status of the batteries and a reference shall be available through the discrete outputs, to alert the Operator that the batteries should be changed. Each controller shall be supplied with an internal lithium battery which shall retain the program during power outages for up to one year.

5. Each unit shall be supplied with sufficient memory to implement the specified control functions plus a reserve capacity of 20 percent of the total provided. This reserve capacity shall be totally free from any system use. The memory shall be programmed in a multi-mode configuration with multiple series or parallel contacts, counters, timers, and arithmetic functions.

6. Controllers: Each programmable controller shall be capable of being programmed with an IEC61131-3 compliant software using simple "ladder diagram" language, and Sequential Functional Blocks. It shall be easily reprogrammed locally with a portable laptop computer or from a remote location via the control system network.

7. Data Communication: Each programmable logic controller shall be equipped with, or have access via linked backplane to, communication options as required (and in the quantities indicated) on the Network Block Diagrams.

8. CPU: CompactLogix 5380 processors shall support a minimum of .6MB of user memory and 2GB of non-volatile memory. CompactLogix L33ER processor shall support a minimum of 2MB of user memory and 1GB of non-volatile memory. A fully commented copy of the active program and I/O tag set shall be stored on the Flash card.

9. Manufacturer: The Filter Building PLC Panel programmable logic controller shall be as manufactured by **Rockwell Automation, no equal**. Where indicated on the Network Block Diagrams, processor shall be **AB CompactLogix 5380** (or better as recommended by the CONTRACTOR to support I/O and communication requirements) with redundant power supplies (as required by the contract drawings). Where indicated on the Network Block Diagrams, Filter Vendor Package PLC processors shall be **Rockwell Automation CompactLogix Model L33ER** with Compact Flash card, integral dual Ethernet port and USB port (or better as recommended by the Vendor to support I/O and communication requirements).

B. PLC Power Supply

1. Redundant “hot-standby” 24vdc power supplies shall be furnished where indicated on the Control Panel Elevations drawing. Filter Vendor Package PLC power supply shall be **AB 1769-PB4** for the **CompactLogix L33ER**.

2. CompactLogix 5380 PLC power shall be provided as follows:

   a. MOD Power - MOD power is a DC power source that is required to operate a CompactLogix 5380 system. It is system-side power that powers the system and lets modules transfer data and execute logic. System-side power is provided through the MOD Power Removable Terminal Block (RTB). The MOD power bus shall only use DC power. Do not connect AC power to the MOD power bus. Total continuous current draw across the MOD power bus shall not be more than 10A maximum at 18 – 32VDC. Inrush current requirements must be considered when calculating total MOD power bus current draw in the system. The CONTRACTOR shall size MOD power supplies as required to power the connected load.

   b. SA Power—SA Power is field-side power that powers some Compact 5000 I/O modules and field-side devices that are connected to them. Field-side power is provided through the SA Power RTB. Some Compact 5000 I/O modules draw current from the SA power bus and then pass the remaining current to the next module. Some I/O modules only pass current along to the SA power bus to the next module. The system may have multiple SA power buses. The first SA power bus starts at the controller and passes across the I/O modules that are installed to the right of the controller. If additional SA power buses are required, a 5069-FPD field potential distributor shall be used to establish the new bus. Each new SA power bus is isolated from the power bus to its left and has a shared common unique to that bus. All inputs that draw current from an SA power bus to power field side devices shall return through circuitry to the SA terminal on that SA power connector. If a SA power bus uses DC voltage, the total continuous current draw across the bus shall not be more than 10A maximum at 18 – 32VDC. Inrush current requirements must be considered when calculating total SA power bus current draw in the system. The CONTRACTOR shall size SA power supplies as required to power the connected load.

   c. Separate external power supplies shall be used for MOD power and SA power.

3. Design features of the PLC power supplies shall include diagnostic indicators mounted in a position to be easily viewed by the user. These indicators shall provide the operator with the status of the DC power applied. In addition, a means of disabling power to the PLC shall be possible from a power disconnect switch mounted in a position easily accessible by the operator.

4. The power supplies shall offer fuse protection.

C. **PLC Input/Output (I/O) Modules**: All I/O housings and modules shall be suitable for hostile industrial environments as described in Paragraph 2.3.A.1 above. All I/O modules shall be isolated and conform to IEEE Surge Withstand Standards and NEMA Noise Immunity Standards. I/O shall be 4-20 mA DC for all analog inputs and outputs. Discrete inputs shall be 24 VDC for the Plant PLCS and 120VAC for the Filter Vendor PLCS. Discrete outputs shall be dry relay contacts. Modules shall be removable without having to disconnect wiring from the module's terminals by means of a swing-arm or plug-in wiring connector.

D. Each PLC location shall contain the I/O modules required to provide all of the I/O points contained in the I/O List plus available capacity to accommodate all future points. As a

minimum, each PLC location shall contain an installed spare capacity of 20 percent of each type of I/O used at that location. Circuit components for both remote input and output shall be mounted on plug-in passive backplanes and keyed to prevent incorrect module insertion. Furnished I/O modules and housing chassis shall be as manufactured by **Rockwell Automation**.

1. Discrete Input Modules: Defined as contact closure inputs from devices external to the programmable controller module. Individual inputs shall be optically isolated to prevent possible damage due to electrical transients. The modules shall have LEDs to indicate status of each discrete input. Plant PLCS input signal level shall be 24 VDC. Vendor PLCS input modules shall be 120VAC. The input module shall have a maximum of 16 points each.

2. Discrete Output Modules: Defined as contact closure outputs for ON/OFF operation of devices external to the programmable controller module. The output modules shall be optically isolated to separate module logic and bus circuits from field power. All output modules shall have LEDs to indicate status of each output point. Each output point shall be individually isolated, fused and connected to interposing relays. Interposing relays shall have contact ratings for the attached loads. The PLC system shall offer discrete output hardware consisting of the following types:

    a. 5069 relay outputs rated at 5 – 264 VAC/125 VDC

    b. 1769 relay outputs rated at 5 – 265 VAC/5 - 125 VDC

3. Analog Input Modules: Defined as 4 to 20 mA DC signals, where an analog to digital conversion is performed with a minimum of 16-bit precision and the digital result is entered into the processor. The analog to digital conversion shall be updated with each scan of the processor. Analog input modules shall have eight differential inputs each. Input modules shall be source or sink to handle 2-wire or 4-wire transmitters respectively. The CONTRACTOR (or Vendor package Supplier) shall provide current loop isolators as required to break ground loops.

4. Analog Output Modules: Defined as 4 to 20 mA DC output signals where each output circuit performs a digital to analog conversion (minimum 12-bit precision) with each scan of the processor. Each analog output module shall have four isolated output points which shall be rated for loads of up to 1200 ohms. The CONTRACTOR (or Vendor package Supplier) shall provide current loop isolators as required to break ground loops.

2.4 PANEL HARDWARE

A. CONTRACTOR furnished fiber optic patch panels (FOPP) shall be as manufactured by **Belden, MIPP Model or equal**.

B. CONTRACTOR supplied Cat6 UTP Ethernet plenum cables and patch-cords shall have installation and performance adhering to the requirements of ANSI/TIA/EIA-568-C.2.

C. The CONTRACTOR shall provide fiber optic patch cables which meet the performance characteristics of the plant network fiber optic cabling. Single mode, UL rated 50-micron fiber

patch cables shall be obtained from the primary fiber optic cable manufacturer with terminators.

D. Reuse Filter PLC Control cabinet DLR capable managed Ethernet switch shall be industrial with dual gigabit fiber uplink ports. Units shall be UL-508 rated and IEC 61850-3 rated. PoE will not be used for any device. Ethernet switch shall be as manufactured by **Cisco, Ubiquiti, or equal**. Required port density (using SFP modules) shall be as indicated on the Network Block diagrams with a minimum of two spare ports. For all unused Ethernet switch access ports, the CONTRACTOR shall secure the port to allow only registered MAC addresses to access the network. SFP uplink modules shall be minimum rated one gigabyte.

E. Reuse Filter PLC panel I/O Ethernet switch shall be Stratix 5700 or equal with a minimum of 10 ports for field connected Ethernet devices

2.5 FIELD INDUSTRIAL WORKSTATION COMPUTER

A. **Field Industrial Workstation Computer:** Where indicated on the Network Block Diagram, the CONTRACTOR shall install an industrial monitor and Intel processor based, panel-mounted, UL-listed, industrial panel PC suitable for browser-based applications and server client access. The NEMA 4X, 24Vdc panel-mounted unit shall be equipped with the following minimum:

1. 15-inch XGA (1024x768, 18-bit color) integrated, thin-film transistor (TFT) Active-Matrix Liquid Crystal, LED Backlit touchscreen.

2. System Memory: 8GB memory, 64GB of storage

3. One RS-232 port.

4. Two USB 2.0 ports.

5. One Secure Digital (SD) card slot

6. Two 10/100-BaseT RJ-45 Ethernet port.

Units shall be designed to operate in 0 to 50 degree C temperature range at up to 90% humidity, non-condensing. Each panel-mounted industrial monitor unit shall be as manufactured by **Hope Industrial Systems. Each panel mounted PC shall be as manufactured by OnLogic, or equal, to be used as an Industrial Automation Software Ignition Client.**

2.6 SOFTWARE

A. **General**: All PLC programming, communication, and data gathering software shall be in accordance with this section and 40 90 10.

2.7 SPARE PARTS

A. PLC system spare parts shall be provided in accordance with Specification Section 40 91 00 - Process Control and Instrumentation Systems.

PART 3 — EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies which it furnishes. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies it furnishes.

B. All components of the PLCS including all communication cabling shall be the installation responsibility of the CONTRACTOR unless specifically noted otherwise. The installation of the communication network (inclusive of the Vendor package systems) shall be the complete installation responsibility of the CONTRACTOR including all cables, connectors, transceivers, and any required electrical grounds. Grounding shall be shown on submittal drawings and/or the approved Vendor submittal drawings. After installation of the PLCS is completed, the installation shall be inspected jointly by the CONTRACTOR and the package Vendor representative. Any problems shall be corrected, and when both are satisfied with the installation, a written certification of the installation shall be delivered to the Engineer. The certification shall state that all PLC communications, I/O modules, system grounds, communication networks, field terminals, and all other components of the PLCS System have been inspected and are installed in accordance with the manufacturer's guidelines, the Vendor requirements, and the requirements of the Contract Documents.

3.2 FACTORY TEST

A. **General**: Prior to the delivery and installation of the PLCS at the job site, but after the procurement, assembly, and configuration/programming of all components, the CONTRACTOR shall conduct a factory test. In identical fashion, each in-contract primary package Vendor shall also be required to conduct a factory test of the associated package VPLCS. Tests shall be witnessed by representatives of the Owner and the Engineer. Each factory test is intended to be a complete PLCS. Factory testing shall demonstrate the functionality and performance of specified features of the PLCS. Each test shall include (as applicable) verification of all PLCS, field terminals and I/O points along with their respective and/or control displays. Each display shall be checked. A complete system checklist shall be available during the test for recording results of selected points. The CONTRACTOR shall also be responsible for coordinating witnessed factory testing of the Vendor packages with Engineer approval as detailed herein.

B. **Test Setup**: The complete PLCS system shall be assembled and interconnected on the CONTRACTOR's factory floor. The interconnections shall include all communication cable segments for the individual node LANs and the ~~workstation~~ networks to simulate as closely as possible the eventual job site installation. (Exceptions to this arrangement must be detailed in the CONTRACTOR's submitted FAT plan and approved by the Engineer prior to FAT execution.) The PLC's, ~~PLC programming terminals~~, field terminals, and communication devices shall be loaded with their applicable software packages and configuration programming. PLC input and output modules shall be installed in their assigned housings and wired to field termination points in the enclosures. The CONTRACTOR shall have a complete and current set of wiring diagrams, a PLC register list, and a listing of displays for review throughout the test.

Vendor package VPLCS testing shall be conducted by the associated Vendor at the Vendor facility and subject to identical test setup and coordination requirements.

C. The CONTRACTOR shall schedule factory testing after receiving approval of the factory test procedures submittal. The scheduling effort shall include coordination of the Vendor factory tests to avoid scheduling conflict and ensure consistency in planning and execution. A written factory test coordination plan shall be submitted by the CONTRACTOR to the Engineer for review and approval at least 6 weeks prior to the start of the first test. The coordination plan shall include a complete schedule of factory tests with the test host contact name/number, location, start date, expected duration and schedule contingency. To support this segregated testing approach, the CONTRACTOR shall manage the following exchanges between all concerned parties at least 30 days prior to a scheduled FAT test:

1. Shared I/O addressing or messaging block arrangements to support sharing of data between the Vendor and the Plant Integrator control programs. The factory test host will be expected to provide a test PLC or mimic application to support simulation of shared I/O necessary to allow full logic verification and scenario testing.

2. Share of control screen development standards, navigation schemes, system access control, handling of web-enabled devices and control-mode coordination (as established during the Specification 40 95 20 Graphics Meetings) to ensure that the Vendor package control screens seamlessly integrate into the Plant Integrator developed HMI system.

3. Note: control mode coordination is specifically intended to address management of Vendor package control between the Vendor OIT and the Plant HMI.

4. Share of Ethernet switch configuration requirements and network addressing schemes (as established during the Network Coordination Meeting) to ensure seamless integration of Vendor network equipment and nodes into the plant control system network.

5. Share of each Vendor I/O list, alarm list and native screen inventory with the Plant Integrator.

D. **Test Procedure**: Each factory test shall be conducted in accordance with the previously submitted and approved test procedures. Test procedures shall include written descriptions of how individual tests shall be performed and shall incorporate testing the following features as a minimum (as applicable to supplied equipment). All testing shall be completed in one continuous factory test which may extend over several continuous days, as necessary. The witnessing Engineer reserves the right to more closely examine any system, component, or logic structure as necessary to confirm conformance with the contract requirements.

1. Communication: Verify all network components can communicate over the control system network using the contract required protocols and mediums.

2. Power Failure: Redundant power supply testing

3. Software Applications: The primary software applications of each field terminal, as listed in this specification section shall be reviewed for proper installation and configuration and all link and software integration points confirmed through use of proxy machines (furnished temporarily by the FAT host – CONTRACTOR or package Vendor - to facilitate testing as necessary) and/or introduction of mimic test data. If applicable, the ability to upload and download files to the vendor PanelView operator interface from the network will be tested. Database templates shall also be reviewed to confirm adherence to contract requirements.

4. I/O Verification: All I/O terminal point wiring shall be verified for all PLC's. The FAT host shall provide a means of easily introducing a discrete or variable analog signal to all I/O points. In addition, a means of establishing communications with any field network device, using the contract required protocol, shall be demonstrated. Signals shall be verified at the associated PLC register and the operator interface.

5. Control Displays: The ability to enter new setpoints, vary control modes, and adjust control parameters shall be demonstrated. The lack of ability to change these items without the correct security level or control mode selection (as applicable to management of Vendor package controls) shall also be demonstrated. Confirmation of changes shall be obtained by checking appropriate PLC registers. Typical PID, VFD, actuator and motor-starter control faceplates shall also be tested. Custom interfaces and control logic for system processes shall also be reviewed in detail making use of tools employed under the I/O verification testing to observe PLC logic and control screen responses with respect to the descriptions in Specification Section 40 90 10 – Control Strategies and/or Engineer approved Vendor control narratives.

6. Display Screens: Incorporation of all approved submittal displays shall be confirmed. Overall quality and accuracy of the control screens shall be reviewed (based on the Graphics' Meeting minutes). Verification of all points on each display screen, and the ability to call up displays via point and click targets or function keys. The ability to print out a display screen shall also be tested. Test web-based displays (links to plc web cards) OIT web access shall be configured to be disabled.

7. Alarm handling: Verification of alarm logging, summary display, outputs to horn/beacons and the ability to disable alarms. Silencing and acknowledging of alarms shall also be tested. Refer to the Specification Section 40 90 10 for any additional specified features.

8. Trend Displays: Pre-configured displays shall be checked for functionally including both historical and real time data and trend printing. A demonstration of the generation of a custom configured trend with all variables shall be performed.

9. All components shall be individually inspected to confirm adherence with contract specification documents. Panel and panel equipment shall be inspected for appropriate installation, spacing, power, surge protection, grounding, cooling, and labeling.

10. Ethernet switch configuration

E. **Test Report**: The FAT host –Package Vendor - shall record the results of all factory testing on pre-approved test forms which the Engineer's representatives shall sign. A copy of the

completed test forms and a report certifying the results shall be provided to the Engineer by the CONTRACTOR within 10 days of completing the test.

F. **Rework and Retest**: If the PLCS or VPLCS does not operate as required, the FAT host – package Vendor - shall make whatever corrections are necessary, and the failed portion of the test shall be repeated. If, in the opinion of the Engineer's representative, the changes made by the FAT host - CONTRACTOR or package Vendor - to affect such a correction are sufficient in kind or scope to effect parts of system operation already tested, then the affected parts shall be re-tested also. If a reliable determination of the effect of changes made by the FAT host - CONTRACTOR or package Vendor - cannot be made, then the Engineer's representative may require that all operations be re-tested. The CONTRACTOR shall bear all its own costs for the factory test, including any required re-testing.

G. All Engineer's and Owner's travel and per diem costs for factory re-testing (inclusive of package Vendor re-testing) shall be borne by the CONTRACTOR.

3.3 CALIBRATION, TESTING, AND INSTALLATION

A. **Calibration**: All analog inputs and outputs of the PLC shall have their calibration checked at a minimum of 4 points to verify consistency with the balance of the analog loop. This calibration check shall be done in conjunction with the analog loop tests specified in Specification Section 40 91 00 - Process Control and Instrumentation Systems. Workstation / field terminal displays and PLC registers shall both be verified for correctness.

B. **Testing**: After the PLC installation has been certified and the analog points have been calibrated, the PLC shall be tested to verify that all discrete inputs and outputs of the PLC system, control panel operator interfaces, and plant SCADA screens are correct. All points shall be checked "end to end." For example, valve status inputs shall be checked by stroking the valve and a pump start output shall be checked by using it to start the pump. Simulated testing shall be allowed only when no practical alternative exists. Plant SCADA workstation and field terminal displays shall be verified for correctness simultaneously. An I/O checklist shall be used to record test results and a copy provided to the Engineer upon completion.

C. **System Testing**: When the PLC installation has been certified and analog loop calibration and discrete I/O testing have been completed, system testing shall be performed in accordance with the approved test procedures. System testing shall operate the various systems of the facility to verify compliance with all functional requirements specified, including the automatic control modes and PLC interlocks described in the control strategies contained in Specification Section 40 90 10 of this Section. Tests which fail to demonstrate the required operation shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the Engineer.

D. Each field terminal display including trend screens, reports, control screens, and alarm summaries and logs shall be verified for correctness during the system testing phase of this project. During system tests, the CONTRACTOR and package Vendor (as applicable) shall have a representative on site continuously who is capable of troubleshooting and modifying the PLC system configuration programming.

E. The CONTRACTOR shall submit to the Engineer a system testing completion report when each process system, Vendor package and all aspects of the configuration software have been

successfully tested as described herein. The report shall note any problems encountered and what action was required to correct them. It shall include a clear and unequivocal statement that the control systems have been thoroughly tested and are complete and functional in accordance with all specification requirements.

F. **Start-Up Test**: The support detailed below shall be provided as part of the Work.

1. For each Vendor package system and the Reuse Building PLCS, the CONTRACTOR shall be responsible for organizing start-up support to include the package Vendor start-up personnel, electrical and mechanical support personnel, the Engineer and/or the Owner's representatives – all as required during the start-up period to produce a fully operational system.

2. Refer to Specification Section 40 91 00 - Process Control and Instrumentation Systems Part 3 for additional details.

3.4 TRAINING

A. Refer to Specification Section 40 91 00 – Process Control and Instrumentation Systems Part 3 for additional details.

3.5 LADDER LOGIC DOCUMENTATION

A. All PLC ladder logic shall be fully annotated by providing a descriptive label for all relays and function blocks and functional description of each rung.

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SECTION 40 95 20
PLC-BASED CONTROL SYSTEMS SOFTWARE

PART 1 — GENERAL

1.1 THE REQUIREMENT

A. **General**: The CONTRACTOR shall furnish, supervise installation, assemble, configure, program, and place into service the PLC-based control system, hereafter called the PLCS, specified under this Section and in Specification Section 40 95 10 - PLC-Based Control Systems Hardware, all in accordance with the requirements of the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS.

A. PLCS software reference specifications, codes, and standards shall be provided in accordance with Specification Section 40 91 00 - Process Control and Instrumentation Systems.

1.3 CONTRACTOR SUBMITTALS

A. **Shop Drawings**: PLCS submittals shall be in accordance with Specification Section 40 91 00. PLCS software submittals shall, however, be made separately from other process control and instrumentation system submittals.

B. **Software Submittals**: The software submittal shall be a singular all-inclusive submittal which shall include but not be limited to:

1. Complete description of the standard application software programs, operating system, and utility programs to be furnished, including modifications and explanation of how the specific functional requirement will be met. A cross reference between the specification and the software submittal shall be provided to allow the ENGINEER to clearly identify how each specified section or function is being met by the CONTRACTOR.

2. A complete set of programmed software algorithms with:

   a. Individual coil register and variable description.

   b. Subroutine, Rung, Program, and Program Group with complete detailed comments.

   c. Memory, coil, register and variable usage mapping.

   d. Source Code of all High-Level Program Language Modules specifically created by the CONTRACTOR for this project.

3. A complete written narrative of control strategies which depict all monitoring and control functions on a loop-by-loop basis. Narratives shall enumerate the signal point name, signal description, associated PLC number, associated graphic displays, and

system functions activated by the signal (i.e., interlocks, alarms, logs, etc.). The written narrative shall follow the format shown in Specification 40 90 10 Control Strategies, adding detail to fully explain as-programmed control strategies.

4. A complete listing of the PLC database for each data point with relevant parameters such as range, active state, contact orientation, limits, incremental limits, I/O card slot number and rack number, I/O hardware address and PLC assignment. The list shall be divided and grouped by PLC, and divided into type of I/O. In addition to the active I/O, the list shall also include implemented spare I/O. Final format shall be approved by the ENGINEER..

A. **Display and Report Submittals**: After all software submittals required herein have been approved by the ENGINEER, the CONTRACTOR shall submit the following items. Favorable review and implementation of these submittals is required prior to the start of system testing.

1. All HMI display submittals (both graphic and trend displays) shall be in full color as they will appear on the HMI display. This submittal shall be prepared after the requisite Graphics Meetings specified in this Section.

2. Each display shall be uniquely titled. Locations for process data shall be clearly identified either using simulated data or by showing variables on the displays and providing a reference list describing those variables. All dynamic points shall be identified by tag number as a minimum and their operation shall be described on separate sheets (color change, symbol change, etc.). PDF submittals (with screen prints in color) are required for review by the ENGINEER. One set will be returned with comments.

3. All periodic reports for the process. Locations for process data shall be clearly identified, either using simulated data or by showing variables on the report and providing a reference list describing those variables. PDF reports shall be submitted for review by the ENGINEER. One set will be returned with comments.

B. **Additional Requirements**: The following items shall be submitted with the final sets of Owners Manuals required 15 days prior to the plant operational test.

1. All software specified in this Section.

2. All program manuals supplied by the manufacturer(s) with the standard software packages.

3. All original program disks and/or electronic media supplied by the manufacturer(s) with the standard software packages, including any program revisions or updates issued by the manufacturer(s) during the construction period.

4. All PLC program, HMI, and panel computer configuration program files stored on labeled electronic media. The configuration file media shall also be updated as required if any changes or corrections are required in the programming prior to project completion.

5. A change of ownership registration form for each standard software package supplied under this project to allow the OWNER to register the software with the manufacturer.

C. **Operations Reference Manual**: The CONTRACTOR shall prepare and submit an Operations Manual for the operator interface system for use by the plant operators. This manual shall be a white view binder and shall contain the following:

1. An index to the manual.

2. A list of display screens, trends, and reports, with display name and description.

3. A list of the control screens with the display names and description. It shall also provide a summary of possible commands and operator inputs to these screens including setpoints. All control actions shall be included.

4. A PLCS block diagram with names and locations of major components.

5. Instructions for manually printing screens or reports, both real time and historical as applicable.

6. A summary of security levels and their privileges and limitations.

7. Spaces for operators to make notes.

8. A copy of this manual shall be provided to each operator during. The training class shall include a review of this manual with the operators in addition to more detailed instruction on the panel computer configuration and its use.

9. A fully searchable electronic version of the manual (in PDF format) with all contents listed above shall be integrated into the control system HMI. Access shall be made available under a help index.

1.4 MANUFACTURER'S REPRESENTATIVE

A. PLC-based PLCS hardware manufacturer’s representative services shall be provided in accordance with Specification Section 40 95 10.

PART 2 — PRODUCTS

2.1 GENERAL

A. This Section covers the furnishing of standard and customized software fully installed and configured in the control system specified herein. It is the intent of this Specification to have the CONTRACTOR furnish the latest generation, standard, field proven, fully debugged and supported PLC software package for this application with a minimum of additions or changes. Customized or specially written software shall be furnished if required to meet all the functional requirements specified herein. Any custom applications software required shall be fully integrated into the basic software and shall not require unique command structures. No

attempt has been made to list all software or list all characteristics of software required by the instrumentation supplier to meet the functional requirements specified herein.

1. Software specified herein is described in broad, functional categories. The instrumentation supplier shall furnish a complete software package including the functional requirements specified herein along with whatever additional software is required for proper and efficient operation of the PLCS System.

2. The software package shall provide a system capable of controlling system level activities and a higher-level process control language allowing the operator to monitor and control the process through an interactive human interface. The software environment shall support a multi-programming atmosphere allowing concurrent execution of more than one program in a background/foreground mode or multi-tasking mode.

3. Throughout the execution of all software modules, the operator shall be presented with all the command or operation choices available at that point in the program using sufficient verbiage or symbols to make the choices self-explanatory and unambiguous. Question and answer or fill-in-the-blank requests shall only be permitted where file names, tag names, or other unique text or numerical information is required.

2.2 HARDWARE

A. **General**: The PLC, panel computer, and communication equipment, etc., shall be provided under provisions of Specifications Specification Section 40 95 10.

2.3 PLC SOFTWARE

A. **PLC Programming Software**: All PLC programming shall be accomplished using a standard version of Studio 5000 supported by the installed CompactLogix firmware.

1. All programming, monitoring, searching, and editing shall be accomplished using this PLC programming software. It shall be usable while on-line (connected directly to the PLC or indirectly via the control system network), off-line and in the emulation mode (no PLC required). The PLC programming software shall display multiples of series and parallel contacts, coils, timers, counters, and mathematical functions blocks. The software shall be able to monitor the status of all inputs, outputs, timers, counters, and coils. It shall have the capability to disable/force all inputs, outputs, and coils to simulate the elements of the ladder logic by means of color change. It shall include a search capability to locate any address or element and its program location. PLC status information, such as error indication and amount of memory remaining shall be shown on the display screen.

2. The PLC programming software shall have the capability to generate a PLC program printout which is fully documented. Fully documented program listings shall have appropriate rungs, address, and coils shown with labels, descriptors, and identifiers. Comments shall clarify to a reader what each segment of the program accomplishes. A fully documented listing shall also include a cross reference report of program addresses.

3. The PLC programming software package shall be able to monitor and/or control PLCs via the communication network. It shall contain diagnostics to collect troubleshooting and performance data and display it in easy-to-understand graphs and tables.

4. The PLC programming software shall have an I/O database that is fully compatible with, and accessible by, the contract specified HMI system software.

B. **Operator Control**: All programming commands related to changing system configuration or controlling field devices shall be performed only through the HMI and shall require more than one keystroke to protect against inadvertent operations. The HMI configuration commands shall require operator confirmation of a requested action before any change is made. This shall apply to changes in the algorithms, control sequences, and similar configuration related actions, as well as file copy and file delete commands. For any sequence requiring operator confirmation, the operator shall be able to cancel the operation at any point prior to executing the command.

C. **Reboot Operation**: The PLC shall reload the most recently entered control and alarm setpoints on reboot. Changing these setpoints or alarms shall require operator action. Rebooting a workstation shall not change these alarms or setpoints.

2.4 PANEL COMPUTER AND HUMAN MACHINE INTERFACE (HMI) SOFTWARE

A. **General**: HMI software provided for the Reuse Filter Building PLC Panel operator interface panel computer shall be per the Owner's standard: **Ignition by Inductive Automation**. CONTRACTOR shall configure the panel computer operator interface as an Ignition client. All HMI software capabilities and methods of interaction shall be as per Ignition specifications.

1. The system shall provide a mechanism for accepting configuration input directly from the touchscreen.

2. All configuration changes shall be capable of being made on-line, while the system is operating. Data definitions, operator displays, etc. shall be capable of being modified, added, or deleted without having to interrupt the data acquisition.

4. The system shall provide complete user documentation, including examples of how to operate the various modules within the system. An on-line "help" facility shall provide useful, context-sensitive information on the operation of the package. This help facility shall be capable of being invoked on-line through a point-and-click operation.

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B. **Data Handling Capabilities:**

HMI shall have the following data handling capabilities:

1. OPC-based and communicates with virtually any OPC server.

2. SQL-based (JDBC) and connects to any number of Databases.

3. Built-in PLC drivers and connects to any PLC (Allen-Bradley, Siemens, Modbus, etc.) through OPC.

4. Supports any web services and launches anywhere.

5. Connects to devices such as barcode scanners, scales, and sensors.

6. Connects to any mobile device such as wireless smartphones and tablets.

7. Connects to any touch panel screen

C. **I/O Device Communications**

HMI shall have the following available drivers:

1. Logix Driver – Connect to Allen-Bradley Logix family devices with firmware v21+.

2. Modbus Driver - communicate with any device that supports the Modbus protocol, that is, the Modbus TCP and Modbus RTU over TCP protocols. Connect directly to devices that support Ethernet communications or also connect to Modbus devices through a Gateway device.

D. **Networking and Distributed Operation**

The HMI platform shall support multiple architectures including:

1. Single Server Installs – a single Gateway that can connect to multiple PLCs, databases, and other devices, with a single licensed install. Ability to launch clients on touch panels from one installation.

2. One Server, Multiple Networks – A Gateway that supports dual-NIC servers, and can act as a bridge between multiple networks, or communicate with multiple sites over a corporate WAN.

3. Two Servers, Redundancy - Two server installations can be linked together, so if one server fails, the other takes over and continues executing. All connected clients will be redirected to the backup machine, and historical data will continue to be logged. The transition shall be seamless, meaning processes will never be prevented from executing due to one server going down.

E. **Graphic Capabilities**

HMI Graphics shall include the following capabilities:

1. Unlimited clients per server.

2. Real-time status and control functionality

3. Display real-time alarms

4. Customizable charts, tables and graphs display real-time and historical data. Allows creation of executive dashboards, tracking of key performance indicators (KPIs), and trend views.

5. Allows integration of data from SQL databases. Data entered by operators may be written directly to any database.

6. Vector-based 2D drawing tools allow creation of distinctive screen designs and layouts with shape-building tools for lines, polygons, rectangles, arrows, and circles. Vector graphics allow programmers to create precision shapes and Bézier curves that scale to any size without losing image quality.

7. State dependent settings and dynamic positioning bind shape properties to data values to create animations.

8. Supports advanced functionality using a built-in Python scripting engine.

9. Ability to instantly deploy client updates by making changes to the master project screen on the server and publishing.

F. **Alarm Handling**

Alarming system shall:

1. Allow configuration of logic for how, why, and when alarm notifications are delivered.

2. Manage alarm notification for groups of users, send notifications via email, and allow alarm acknowledgement by the recipient via email.

3. Provides the following types of alarm notification logic

   a. Delay - Hold off on sending notifications until nearby operators are given time to deal with the problem first

   b. Escalation - Elevate alarm notification when operators are not handling alarms.

   c. Consolidation - Combine multiple alarms into a digested message

   d. Selection - Distribute different alarms to different groups of contacts.

G. **Archiving and Reporting**

HMI software shall provide an easy-to-use design interface that allows creation of rich, dynamic, PDF reports, allows the capability to select report data from multiple sources, and can run reports automatically. Capabilities shall include ability to:

1. Generate reports from existing files or create them from scratch.

2. Specify any number of report parameters and data sources

3. Access information from any SQL database, query data from the historian, or event data from the alarm system.

4. Reports can be generated on a preconfigured schedule, on demand, or by event triggers such as tag changes, shift changes, etc.

5. Build complex SQL queries easily using a drag-and-drop query interface

H. **Security Management**

Built-in security settings shall restrict project access to users on different networks, either by restricting specific components in a project, or denying access to a whole project based on user role and network location.

Any client launched shall be secured using SSL protocols. Authentication groups can be used to strictly limit access to certain areas of a project to only the users with appropriate access levels.

I. The HMI software shall be as manufactured by **Inductive Automation: Ignition**

2.5 OPERATION SYSTEM AND APPLICATION SOFTWARE:

A. The operating system and application software shall be provided for each computer as detailed below. (Specific configuration requirements shall be finalized during the Network Coordination Meeting specified in section 40 95 10).

Primary SCADA I/O & HMI Server - Owner's existing Primary Server

Secondary SCADA I/O & HMI Server - Owner's Redundant Server (if exists)

Historian Server - Owner's existing Historian Server

Control Room SCADA Client Workstation - Owner's existing Control Room SCADA Client

PLC Panel Computer – Windows 10 Pro

B. The CONTRACTOR shall register all Rockwell Studio 5000 software licenses with the Rockwell Automation Software Support Program for the entire construction period plus two years after final acceptance. This support shall include 24/7 technical support (email and phone), software upgrades and patches at no additional cost. Software support renewal, as applicable, shall be the sole responsibility of the CONTRACTOR.

C. To address possible version compatibility problems, the version of each software package to be provided shall be reviewed during the Pre-submittal Conference and confirmed during the CONTRACTOR software submittal review process.

2.6 VIDEO TRAINING – Not Required.

2.7 WORKSTATION GRAPHICS GENERATION

A. It is the responsibility of the CONTRACTOR to configure the workstations and to develop, design, engineer, configure and test all the HMI graphic displays required for this project. All this work shall consider the specific needs of the end user. To facilitate this, work the CONTRACTOR shall conduct the following meetings with the OWNER groups:

B. Graphics Meeting No. 1

1. The CONTRACTOR shall chair and develop an agenda for a meeting which shall address the basic criteria to be adhered to in the configuration and development of the HMI graphic displays. At this meeting, which shall be attended by plant managerial personnel, the CONTRACTOR shall distribute sample display formats for illustration purposes. As a minimum, this meeting shall address the following issues:

    a. All facility conventions for identifying tag names and descriptors (this will include process areas, piping, mechanical equipment, tanks, valves, inline equipment, instruments, workstations/servers, control components and network components)

    b. Designation of groups within each plant or station area along with tag names and descriptors.

    c. The assignment of individual control loops and inputs to specific groups.

    d. Organization of the systems universal display hierarchy.

    e. Paging schemes to be used to enable the movement from one display to another.

    f. An itemization of the type of display to be used at each level in the graphic hierarchy (e.g., pre-formatted displays, templates, custom graphics, etc.)

    g. Color convention to be employed on all graphics for the annotation of various status information, differentiation between alarms on the basis of alarm priority, background colors, static field colorization and dynamic field colorization.

    h. The utilization of blinking and conditional text.

    i. Definition of graphic symbolism to be used on the project. This listing shall include but not be limited to symbols to be used for process instrumentation, process equipment, piping, vessels, and valves. All symbolism must be specific as opposed to generic in that shapes must define both function and type (e.g., specific symbols for each valve design, each pump design, each type of flow meter, etc.). If the CONTRACTOR's library of shapes does not adequately describe plant or pipeline conditions, the CONTRACTOR shall develop additional shapes to meet the plants or pipelines requirements.

    j. Definition of all display select commands that enable the operator to move within the display hierarchy.

k. The utilization of cursor movement commands which enable the operator to move within a display.

l. Definition of control input commands which enable the operator to interact with faceplates control stations and custom graphic displays to implement control outputs/functions.

m. Definition of data input commands which enable the operator to enter numeric values into the PLC system.

n. Definition of the utilization of "poke" points or fields which are dynamically sensitive to operator inputs to facilitate operator entry directly into graphic displays.

o. A review of graphic generation procedures.

p. Historian data collection parameters.

q. Electronic O&M production and accessibility at HMI.

r. User groups and process monitoring/control accessibility

s. Overall system navigation and access philosophy and organization of screen monitoring and control data to support.

t. Vendor package control mode coordination – to manage control authority transition from a Vendor package OIT to the Plant HMI and vice versa.

u. Alarm handling, event logging and approach to managing historical alarm and event log access

v. Web-enabled devices web page integration.

w. Control screen wall display compatibility

1. After the adjournment of graphics meeting No. 1, the CONTRACTOR shall prepare and formalize a document titled "GRAPHICS CRITERIA" which shall contain detailed meeting minutes and a definition of all graphic guidelines to be adhered to. This report shall be supplemented by a first draft HMI control screen package which illustrates the incorporation and application of each graphic criteria. The report shall be submitted to the ENGINEER for review / approval within 30 calendar days of the meeting's adjournment. ENGINEER comments will be returned to the CONTRACTOR for action and response review during Graphics Workshop No.2.

C. Graphics Meeting No. 2

1. After the finalization of the overall system-wide graphics criteria, the CONTRACTOR shall develop a second draft HMI control screen package as required to support all

workstations being furnished under this project, taking into account the ENGINEER's first draft review comments. At this meeting, the CONTRACTOR shall submit 5 color hard copies of the complete package and present a navigable version of the HMI control screen package using the project HMI software. During the workshop, the CONTRACTOR will:

a. Review the recorded requirements of Graphics Coordination Workshop No.1 and show how each has been addressed

b. Review the Engineer first draft submittal review comments and show or explain how each has been (or will be) addressed.

c. Review the entire HMI control screen package for overall content completeness

d. Demonstrate approach to input command handling, setpoint management and secure access control.

e. Demonstrate navigability, functionality, and overall quality of delivery.

f. Collect and record all actionable comments received.

D. After the adjournment of Graphics Coordination meeting No. 2 the CONTRACTOR shall prepare a formalized re-submittal of the HMI control screen package for ENGINEER review/approval along with the detailed meeting minutes. Meeting minutes shall be submitted within 5 working days of meeting adjournment and will include an expected time frame for CONTRACTOR delivery of the HMI control screen package re-submittal.

1. The CONTRACTOR shall allow 1 day for each meeting.

E. The following HMI graphic displays shall be developed for this project (as minimum):

1. Reuse Building and related processes.

2. All group alarm displays.

3. All control loop tuning displays.

4. All analog faceplate displays.

5. All key macro icon displays.

6. All database archiving control displays.

7. All customer displays for operator set point entry and recipe displays.

8. All historical trending displays.

9. Control system network configuration and diagnostic displays.

10. Redundant communication diagnostic and control displays.

11. All local node diagnostics (include PLC's, Operator Interfacing Units, and Instruments).

12. All group event displays

13. All vendor developed control screens and web-based interfaces shall also be replicated in the final HMI graphics display set.

2.8 PLC SYSTEM DATABASE

A. The workstation software shall incorporate a disk memory resident database which shall store all software elements necessary to implement all data acquisition, calculation, logging, and reporting functions. The system data base shall be comprised of the following elements:

1. Current data base; includes process status information.

2. Historical data base; includes non-current process status information.

B. **PLC System Documenter**: After system configuration or configuration updates, all information which defines the hardware, control, and display configuration of the PLCS system shall be stored in mass memory within the workstations. The workstations shall be provided with all the intelligence and printing/plotting capabilities to enable the automatic generation of system documentation. All documentation shall be printed/plotted in both a text and graphic format. All documentation shall be accessible in report formats. It is not acceptable to utilize screen prints as a documentation report method. The workstation shall provide the means to produce the following documentation.

1. Current control system databases, (including tags, descriptors, alarm limits, engineering units, associated alarm priority, logical states, etc.) control loops and ladder logic.

2. Definition of the current hardware configuration including locations and associated PLC numbers.

3. Definition of the current display hierarchy and all displays currently in the system.

C. **Data Base Generation**: All software shall be provided to enable historical database generation to be accomplished by a conventional fill-in-the-blanks technique on HMI display formats in which operational characteristics (i.e., name, scan class, alarm limits, etc.) are inserted into linkable prewritten software modules which perform scanning, computational and collection functions. Once the information is transcribed into data records, the database software shall:

1. Read and interpret the information.

2. Manage all process input and output hardware assignments.

3. Generate data files.

4. Perform self-documenting functions such as producing hard copies of listings, main and disk memories, and data sorts by analog input, analog output, contact input and contact output.

D. **Data Acquisition**: Scan blocks shall extract data from the communications network at specifiable rates, condition the signals, convert the data to engineering units in a floating-point format, and store the data to produce an IO database. Typical input signals to be scanned include:

1. Limit, status, or position information from open/close valves, motors, and process monitoring devices such as flow, temperature, and pressure switches.

2. Measured variables such as flows, pressures, levels, temperatures, etc.

3. Measurements, set points, and outputs from all PLC's.

4. Computed values such as inferential measurements.

5. Operational commands from workstations keyboards.

E. **Data Collection**: The CONTRACTOR shall provide programming that collects current values of specified variables from online data storage areas, statistically manipulates data, and creates and maintains an historical database of collected values. Statistical manipulation shall include linear averaging, filtered averaging, and noting of "bad" values. Statistically manipulated data shall then be stored in a historical database.

1. The frequency of historical collection shall be ENGINEER selectable (e.g., once per second, once per month, etc.). The type and quantity of historical data shall be selectable by addition and deletion to/from the historical data base.

2. The CONTRACTOR shall provide adequate and scalable online storage as detailed in section 40 95 10.

3. Historical records (daily) shall be incrementally archived to a network accessible storage and shall be an automatic function.

2.9 REPORTS

A. **General**: The PLCS shall support 2 distinct types of report generation: (a) process reporting which generates logs based on processes or equipment scanned or on manually substituted data and (b) management reports which are comprised of lab derived data and process data. The CONTRACTOR shall provide software resources which process all requests for data collecting, reporting, and translating of data to an industry standard format, for assembling of data to predefined formats and merging data with appropriate heading information, for storage of data in output files associated with an output device and initiation of the appropriate output handling routine. The workstations shall provide for manually initiated reports via an operator interface at each workstation. Reporting functions shall be designed

to report the historical data effectively and clearly. The ordering and amount of historical data, as well as any default specific data to be used, shall be selected by the OWNER facility manager. The detailed formatting of the data on a given line shall be pre-specified by the OWNER facility manager. The OWNER facility manager will select the process inputs that are to appear on any log page and their relative placement across the page, title of the page and column heading for each point. The package shall automatically print the accumulated value and, when necessary, automatically scale the value. The reporting package shall automatically flag any value that was not valid during any part of the reporting interval. Valid output devices shall be printers or interactive workstations. Reporting data (in industry standard format) shall be made available to other software packages for producing reports containing bar charts, pie charts etc.

B. **Process Reporting**: The reporting package shall use the process database to provide historical records for an average of 1,000 selected variables. The software as a minimum shall:

1. Collect process data and make available historical information for a minimum of 40 pages of logs, each page containing up to 10 log points described by individual column headers.

2. Automatically print any combination of up to 10 separate periodic reports consisting of selected pages of the 40 pages noted above. The data to be printed shall be pre-selected by the OWNER operations representative.

3. Period reports shall include an End-of-Day Report, printed at end of the third shift each day, an End-of-Week Report, printed at the end of the third shift on the last day of the week, and an End-of-Month Report, printed at end of third shift on the last day of the month. Although the Daily, Weekly and Monthly Reports shall be printed at the same time, they are different reports and may be structured to satisfy different needs. Each of these five reports shall have its own selection of pages and historical data, chosen independently of the remaining reports.

C. **Overall Management System Reporting**: The reporting package shall provide historical records as per the Owner's reporting requirements.

D. **Configuration of Reports**: It is the sole responsibility of the CONTRACTOR to configure the workstations and to develop, design, engineer, configure and test all the reports required for this project. All this work shall take into account the specific needs of the end user. In order to facilitate this work the CONTRACTOR shall conduct the following meetings with user groups:

1. The CONTRACTOR shall chair and develop an agenda 3 weeks in advance for a meeting which shall address the basic criteria to be adhered to in the configuration and development of the reports. At this meeting, which shall be attended by plant managerial personnel, the CONTRACTOR shall distribute sample formats for illustration purposes. As a minimum, this meeting shall address the following issues:

a. All in-plant and remote site data and conventions for identifying tag names and descriptors.

b. Designation of groups within each plant or station area along with tag names and descriptors.

c. The assignment of inputs to specific categories.

d. Organization of the systems universal report categories.

e. An itemization of the type of report available.

f. Definition of terms to be used on the reports.

g. Definition of all report commands that enable the operator to move within the report editor.

h. The utilization of cursor movement commands which enable the operator to move within a report.

i. Definition of data input commands which enable the operator to enter numeric values into the system.

j. A review of report generation procedures and user accessibility

E. **Report Meetings**: To facilitate the work as described in above item the CONTRACTOR shall conduct the following meeting with the OWNER groups:

1. Report Meeting No. 1: After the adjournment of the report meeting No. 1 the CONTRACTOR shall prepare and formalize a document titled "REPORT CRITERIA" which shall contain detailed meeting minutes and a definition of all report guidelines to be adhered to. This report shall be supplemented by first draft reports package. The reports shall be submitted to the ENGINEER for review/approval within 30 calendar days of the meeting's adjournment. ENGINEER comments will be returned to the CONTRACTOR for action and response review during Reports Meeting No.2.

2. Reports Meeting No. 2 - After the finalization of the overall report format criteria, the CONTRACTOR shall develop a second draft complete reports package, taking into account the ENGINEER’s first draft review comments. At this meeting, the CONTRACTOR shall submit 5 color hard copies of the complete package including:

   a. A review of the report package developed for the process area(s) for content and completeness.

   b. A review of the ENGINEER’s first draft submittal review comments and show or explain how each has been addressed.

   c. A review of all data fields for process information.

   d. A review of all required input commands associated with the report access and control manipulation.

2.10 **Software License and Registration**: All software provided shall be installed and used within the terms of the software manufacturer's license agreement. All software purchased by the CONTRACTOR shall be registered to the CONTRACTOR during the construction phase of this project. During that time, the CONTRACTOR shall be responsible for providing and incorporating minor software package updates issued by the software manufacturer. For example, if version 3.1 of a program is purchased, and versions 3.2 and 3.3 were released prior to project completion, the CONTRACTOR shall be responsible for incorporating these later versions into the final project. The CONTRACTOR would not be responsible for incorporating major software revisions such as the release of a version 4.0 or 4.1.

A. Prior to substantial completion of this project, the CONTRACTOR shall re-register all provided software packages to the OWNER and provide the ENGINEER and OWNER with written confirmation of having done so.

2.11 FACTORY TEST

A. General: Factory testing shall be provided in accordance with Specification Section 40 95 10.

PART 3 — EXECUTION

3.1 INSTALLATION AND CONFIGURATION

A. The PLC-based control system software installation shall be provided in accordance with Specification Section 40 95 10..

3.2 PROGRAMMING, TESTING, AND INSTRUCTION

A. General: The PLC-based control system software calibration, testing, and instruction shall be provided in accordance with Specification Section 40 95 10 - PLC-Based Control Systems-Hardware.

3.3 GRAPHICS SCREENS

A. Workstation screens shall be configured to maximize user friendliness for the plant operators. The process of calling up a display screen shall consist of pointing a mouse cursor at preconfigured targets on the current screen and clicking, or of pushing a function key which shall be selected from a labeled list on the current display. Each screen shall include targets or function key labels to related screens and to the main menu screen.

B. The various required screens shall use text of all capital letters except for certain engineering units. All text shall be horizontal. Screens showing equipment shall include the equipment number and name as used in the Contract Drawings. Total equipment run times shall be displayed as hours and tenths of hours adjacent to equipment symbols. Each screen shall show the current time and date which shall appear in the same place on each screen. As a minimum, the CONTRACTOR shall provide the major control screens detailed below with supporting pop-up control screens for individual pieces of equipment.

C. In the development of the graphic screens, the CONTRACTOR shall make use graphic symbols which closely represent the actual field / control / network equipment depicted and piping and structural images rendered with a graphic representation of the actual construction material and color. The images shall be of suitable resolution so as to present a crisp image with no blurred outlines or borders at the screen resolution best suited to support the furnished workstation displays. Animated GIF files of like quality shall be developed and used to represent operating equipment wherever possible. Compressed graphic file formats (e.g., jpeg) and native vector images shall be used in order to reduce file size; the use of bitmap files shall be minimized. Samples of the type of screen image quality expected to be produced by the CONTRACTOR shall be distributed by the ENGINEER during the Pre-submittal Conference as reference. It shall be understood by the CONTRACTOR that simple two-dimensional schematic representations of the process screens shall not be acceptable. However, the graphic screens shall be balanced to highlight and prioritize prominence of the process readings and equipment status over the supporting (grayscale) background graphics while limiting the use of striking colors which may make the screens difficult to view over long periods of time.

C. The CONTRACTOR shall coordinate the display screen development with the control room display manufacturer to ensure optimum display of control screens as described in the previous paragraph. The images and renderings shall be of suitable HD resolution so as to present a crisp image with no blurred outlines or elongated/compressed images.

D. Display Screens: The CONTRACTOR shall configure display screens to display all status and analog data contained in the PLCS system database. The Contract Drawings, Control Strategies, I/O Schedule, and Specifications shall form the basis of the PLCS system database. Some status and analog points shall be displayed on more than one display screen, especially where it relates to more than one process or is significant to facility operations. Every analog and status value shall appear on at least one display screen. Analog values shall be displayed with appropriate engineering units and shall use techniques such as variable fill and/or color changes to provide clarity. Separate control palettes shall be developed to help segregate control functions from monitoring functions for each process/control area of the plant as well as control/network system maintenance and configuration areas.

E. In addition to screens described in Specification Section 40 90 10 Project Control Strategies, the CONTRACTOR shall provide the detailed screens listed below on all workstations.

- Main Navigation Menu – add Reuse Building to the Main Menu
- Network Architecture
- PLC Status and Diagnostics
- Reuse Building Overview
- Filter 1
- Filter 2
- Secondary Reuse Pumps
- Effluent Return Pumps
- Secondary Reservoir
- Splitter Box and Alum Injection
- Chlorine System
- Help Screen

F. Properties for control system graphics, equipment and PID faceplates, navigation, status and alarm handling, and link management shall be as determined by the OWNER HMI development standards and the outcome of the Graphics Meetings. All “dumb” objects shown for clarity shall be grey in color.

- END OF SECTION -

Instrument Tag	Drawing Number	Instrument Type	Service Description	Low	High	Engineering Units	PLC	Location	Location Drawing No.	Associated Equipment	Area Classification	Signal Detail	Req. Power Supply	Instrument Setpoint	Installation Detail Ref.	Comments	Revision
70-LIT-0030	I-15	RADAR	REUSE WET WELL LEVEL TRANSMITTER	0	20	FT	70- PLC-0100						24vdc				
70-LSLL-0030	I-15	FLOAT	REUSE WET WELL LOW LOW LEVEL SWITCH		4218	msl trip	70- PLC-0100						n/a	4218			
70-PIT-0030	I-15	GAUGE PIT	SECONDARY REUSE HEADER PRESSURE TRANSMITTER	0	300	psi	70- PLC-0100						24vdc				
70-PI-0030	I-15	BOURDON TUBE	SECONDARY REUSE HEADER PRESSURE GAUGE	0	300	psi	70- PLC-0100						n/a				
70-FIT-0030	I-15	MAGNETIC	SECONDARY REUSE FLOW TRANSMITTER		4000	gpm	70- PLC-0100						120vac				
70-PI-0031	I-15	BOURDON TUBE	SECONDARY REUSE PUMP 1 DISCHARGE PRESSURE GAUGE	0	300	psi	70- PLC-0100						n/a				
70-PSH-0031	I-15	MECHANICAL	SECONDARY REUSE PUMP 1 DISCHARGE PRESSURE SWITCH	0	300	psi trip	70- PLC-0100						n/a	180			
70-PI-0032	I-15	BOURDON TUBE	SECONDARY REUSE PUMP 2 DISCHARGE PRESSURE GAUGE	0	300	psi	70- PLC-0100						n/a				
70-PSH-0032	I-15	MECHANICAL	SECONDARY REUSE PUMP 2 DISCHARGE PRESSURE SWITCH	0	300	psi trip	70- PLC-0100						n/a	180			
70-PI-0033	I-15	BOURDON TUBE	SECONDARY REUSE PUMP 3 DISCHARGE PRESSURE GAUGE	0	300	psi	70- PLC-0100						n/a				
70-PSH-0033	I-15	MECHANICAL	SECONDARY REUSE PUMP 3 DISCHARGE PRESSURE SWITCH	0	300	psi trip	70- PLC-0100						n/a	180			
70-PI-0034	I-15	BOURDON TUBE	SECONDARY REUSE PUMP 4 DISCHARGE PRESSURE GAUGE - JOCKEY	0	300	psi	70- PLC-0100						n/a				
70-PSH-0034	I-15	MECHANICAL	SECONDARY REUSE PUMP 4 DISCHARGE PRESSURE SWITCH - JOCKEY	0	300	psi trip	70- PLC-0100						n/a	130			
70-AIT-0030	GI-04	CONTROLLER	ANALYZER TRANSMITTER CONTROLLER	n/a	n/a	n/a	70- PLC-0100						24vdc				
70-AE-0031	GI-04	COLORIMETRIC	SECONDARY REUSE CHLORINE ANALYZER	0.3	10	mg/L	70- PLC-0100						From controller				
70-AE-0032	GI-04	NEPHELOMETRY	EFFLUENT TURBIDITY	0	700	NTU	70- PLC-0100						From controller				
70-PIT-0040	I-16	GAUGE PIT	EFFLUENT RETURN DISCHARGE PRESSURE	0	15	psi	70- PLC-0100						24vdc				
70-FIT-0040	I-16	MAGNETIC	EFFLUENT RETURN DISCHARGE FLOW	0	3500	gpm	70- PLC-0100						120vac				
70-PSH-0041	I-16	MECHANICAL	EFFLUENT RETURN PUMP 1 DISCHARGE PRESSURE SWITCH	0	30	psi trip	70- PLC-0100						n/a	11			
70-PI-0041	I-16	BOURDON TUBE	EFFLUENT RETURN PUMP 1 DISCHARGE PRESSURE GAUGE	0	30	psi	70- PLC-0100						n/a				
70-PSH-0042	I-16	MECHANICAL	EFFLUENT RETURN PUMP 1 DISCHARGE PRESSURE SWITCH	0	30	psi trip	70- PLC-0100						n/a	11			
70-PI-0042	I-16	BOURDON TUBE	EFFLUENT RETURN PUMP 1 DISCHARGE PRESSURE GAUGE	0	30	psi	70- PLC-0100						n/a				
70-PSH-0043	I-16	MECHANICAL	EFFLUENT RETURN PUMP 1 DISCHARGE PRESSURE SWITCH	0	30	psi trip	70- PLC-0100						n/a	11			
70-PI-0043	I-16	BOURDON TUBE	EFFLUENT RETURN PUMP 1 DISCHARGE PRESSURE GAUGE	0	30	psi	70- PLC-0100						n/a				
70-AE-0033	I-15	SAMPLER	AUTOSAMPLER			gpm	70- PLC-0100						24vdc				
70-LSHH-0070	I-14	FLOAT	REUSE BUILDING BASEMENT FLOOD SWITCH		TBD		70- PLC-0100						n/a				

	I/O Type	I/O Count		Add 20% spare for future	Module Quantity	Assumed IO/Module						
	AI	5	Hardwired Analog Input	6	1	8						
	AO	1	Hardwired Analog Output	2	1	4						
	DI	28	Hardwired Digital Input	34	3	16						
	DO	1	Hardwired Digital Output	2	1	16						
	RTD	0	Hardwired Temperature Input	0								
	COUNTER	0	Hardwired Pulse Input	0								
	DSAI	24	Networked Analog Input		0							
	DSAO	59	Networked Analog Output		6							
	DSDI	59	Networked Digital Input									
	DSDO	7	Networked Digital Output									

IO Tag	I/O Type	Signal Type	Description	PID Drawing No.	Processor Cabinet No.	Wiring Diagram No.	Terminal Block(TB) No.	TB Channel No.	Network Node	Comments	Revision	Revision Remark
AIT-0032	DSAI	ETHERNET I/P	SECONDARY REUSE CHLORINE RESIDUAL	GI-04	70-PLC-0100							
AIT-0031	DSAI	ETHERNET I/P	SECONDARY REUSE TURBIDITY	GI-04	70-PLC-0100							
FIT-0032	DSAI	ETHERNET I/P	SECONDARY REUSE CHLORINE SAMPLE FLOW	GI-04	70-PLC-0100							
FIT-0031	DSAI	ETHERNET I/P	SECONDARY REUSE TURBIDITY SAMPLE FLOW	GI-04	70-PLC-0100							
YA-0031	DSDI	ETHERNET I/P	TURBIDITY SENSOR ALARM	GI-04	70-PLC-0100							
YA-0032	DSDI	ETHERNET I/P	CHLORINE SENSOR ALARM	GI-04	70-PLC-0100							
LALL-0030	DI	24v	WET WELL LOW LOW LEVEL	I-15	70-PLC-0100							
LIT-0030	AI	4-20mA	WET WELL LEVEL	I-15	70-PLC-0100							
PIT-0030	AI	4-20mA	SECONDARY REUSE DISCHARGE PRESSURE	I-15	70-PLC-0100							
FIT-0030	AI	4-20mA	SECONDARY REUSE DISCHARGE FLOW	I-15	70-PLC-0100							
PIT-0040	AI	4-20mA	EFFLUENT RETURN DISCHARGE PRESSURE	I-16	70-PLC-0100							
FIT-0040	AI	4-20mA	EFFLUENT RETURN DISCHARGE FLOW	I-16	70-PLC-0100							
LI-0010	DSAI	ETHERNET I/P	FILTER 1 LEVEL	I-13	70-PLC-0100							
PI-0010	DSAI	ETHERNET I/P	FILTER 1 BACKWASH/WASTE SUCTION HEADER PRESSURE	I-13	70-PLC-0100							
UU-0010	DSAI	ETHERNET I/P	FILTER 1 MODE (OFFLINE, FILTERING, BACKWASH, EXTENDED BACKWASH, SOLIDS WASTE, CLEANING, SHUTDOWN AND DRAIN)	I-13	70-PLC-0100							
LAH-0010	DI	24v	FILTER 1 HIGH LEVEL	I-13	70-PLC-0100							
YA-0011	DI	24v	FILTER 1 BACKWASH/WASTE PUMP FAIL	I-13	70-PLC-0100							
YL-0010A	DI	24v	FILTER 1 ONLINE	I-13	70-PLC-0100							
YA-0010A	DI	24v	FILTER 1 GENERAL ALARM	I-13	70-PLC-0100							
YL-0010B	DSDI	ETHERNET I/P	FILTER 1 DRIVE RUNNING	I-13	70-PLC-0100							
YA-0010B	DI	24v	FILTER 1 DRIVE FAIL	I-13	70-PLC-0100							
YL-0010C	DI	24v	FILTER 1 IN BACKWASH	I-13	70-PLC-0100							
YA-0010C	DSDI	ETHERNET I/P	FILTER 1 ALARMS (MULTIPLE)	I-13	70-PLC-0100							
YL-0011	DSDI	ETHERNET I/P	FILTER 1 BACKWASH/WASTE PUMP RUNNING	I-13	70-PLC-0100							
ZSO-0010A	DSDI	ETHERNET I/P	FILTER 1 BACKWASH VALVE 1 OPEN	I-13	70-PLC-0100							
ZSC-0010A	DSDI	ETHERNET I/P	FILTER 1 BACKWASH VALVE 1 CLOSED	I-13	70-PLC-0100							
ZSO-0010B	DSDI	ETHERNET I/P	FILTER 1 BACKWASH VALVE 2 OPEN	I-13	70-PLC-0100							
ZSC-0010B	DSDI	ETHERNET I/P	FILTER 1 BACKWASH VALVE 2 CLOSED	I-13	70-PLC-0100							
ZSO-0010C	DSDI	ETHERNET I/P	FILTER 1 BACKWASH VALVE 3 OPEN	I-13	70-PLC-0100							
ZSC-0010C	DSDI	ETHERNET I/P	FILTER 1 BACKWASH VALVE 3 CLOSED	I-13	70-PLC-0100							
ZSO-0010D	DSDI	ETHERNET I/P	FILTER 1 SOLIDS WASTE VALVE OPEN	I-13	70-PLC-0100							
ZSC-0010D	DSDI	ETHERNET I/P	FILTER 1 SOLIDS WASTE VALVE CLOSED	I-13	70-PLC-0100							
LI-0020	DSAI	ETHERNET I/P	FILTER 2 LEVEL	I-14	70-PLC-0100							
PI-0020	DSAI	ETHERNET I/P	FILTER 2 BACKWASH/WASTE SUCTION HEADER PRESSURE	I-14	70-PLC-0100							
UU-0020	DSAI	ETHERNET I/P	FILTER 2 MODE (OFFLINE, FILTERING, BACKWASH, EXTENDED BACKWASH, SOLIDS WASTE, CLEANING, SHUTDOWN AND DRAIN)	I-14	70-PLC-0100							
LAH-0020	DI	24v	FILTER 2 HIGH LEVEL	I-14	70-PLC-0100							
YA-0021	DI	24v	FILTER 2 BACKWASH/WASTE PUMP FAIL	I-14	70-PLC-0100							
YL-0020A	DI	24v	FILTER 2 ONLINE	I-14	70-PLC-0100							
YA-0020A	DI	24v	FILTER 2 GENERAL ALARM	I-14	70-PLC-0100							
YL-0020B	DSDI	ETHERNET I/P	FILTER 2 DRIVE RUNNING	I-14	70-PLC-0100							
YA-0020B	DI	24v	FILTER 2 DRIVE FAIL	I-14	70-PLC-0100							
YL-0020C	DI	24v	FILTER 2 IN BACKWASH	I-14	70-PLC-0100							
YA-0020C	DSDI	ETHERNET I/P	FILTER 2 ALARMS (MULTIPLE)	I-14	70-PLC-0100							
YL-0021	DSDI	ETHERNET I/P	FILTER 2 BACKWASH/WASTE PUMP RUNNING	I-14	70-PLC-0100							
ZSO-0020A	DSDI	ETHERNET I/P	FILTER 2 BACKWASH VALVE 1 OPEN	I-14	70-PLC-0100							
ZSC-0020A	DSDI	ETHERNET I/P	FILTER 2 BACKWASH VALVE 1 CLOSED	I-14	70-PLC-0100							
ZSO-0020B	DSDI	ETHERNET I/P	FILTER 2 BACKWASH VALVE 2 OPEN	I-14	70-PLC-0100							
ZSC-0020B	DSDI	ETHERNET I/P	FILTER 2 BACKWASH VALVE 2 CLOSED	I-14	70-PLC-0100							
ZSO-0020C	DSDI	ETHERNET I/P	FILTER 2 BACKWASH VALVE 3 OPEN	I-14	70-PLC-0100							
ZSC-0020C	DSDI	ETHERNET I/P	FILTER 2 BACKWASH VALVE 3 CLOSED	I-14	70-PLC-0100							
ZSO-0020D	DSDI	ETHERNET I/P	FILTER 2 SOLIDS WASTE VALVE OPEN	I-14	70-PLC-0100							
ZSC-0020D	DSDI	ETHERNET I/P	FILTER 2 SOLIDS WASTE VALVE CLOSED	I-14	70-PLC-0100							
LAHH-0050	TBD	TBD	SECONDARY RESERVOIR HIGH HIGH LEVEL	I-15	70-PLC-0100							
FC-0033	AO	4-20mA	AUTOSAMPLER FLOW PACING SIGNAL	I-15	70-PLC-0100							
HS-0035A	DO	24v	CHLORINE BOOSTER PUMP START COMMAND	I-18	70-PLC-0100							
YL-0035A	DI	24v	CHLORINE BOOSTER PUMP READY	I-18	70-PLC-0100							
YL-0035B	DI	24v	CHLORINE BOOSTER PUMP RUNNING	I-18	70-PLC-0100							
YA-0035	DI	24v	CHLORINE BOOSTER PUMP FAIL	I-18	70-PLC-0100							
LAH-0051	DI	24v	FILTER SUMP HIGH LEVEL	I-14	70-PLC-0100							
LAHH-0051	DI	24v	FILTER SUMP HIGH LEVEL	I-14	70-PLC-0100							
YL-0051	DI	24v	FILTER SUMP PUMP 1 RUNNING	I-14	70-PLC-0100							
YA-0051	DI	24v	FILTER SUMP PUMP 1 FAIL	I-14	70-PLC-0100							
YL-0052	DI	24v	FILTER SUMP PUMP 2 RUNNING	I-14	70-PLC-0100							
YA-0052	DI	24v	FILTER SUMP PUMP 2 FAIL	I-14	70-PLC-0100							
YA-0100	DI	24v	PANEL INTRUSION	I-09	70-PLC-0100							
EA-0100A	DI	24v	UPS FAIL	I-09	70-PLC-0100							
EA-0100B	DI	24v	PRIMARY 24VDC POWER SUPPLY FAIL	I-09	70-PLC-0100							
EA-0100C	DI	24v	SECONDARY 24VDC POWER SUPPLY FAIL	I-09	70-PLC-0100							
LAHH-0070	DI	24v	REUSE BUILDING BASEMENT FLOOD	I-14	70-PLC-0100							
FAH-0030	DI	24v	REUSE BUILDING EYEWASH SHOWER ALARM	I-16	70-PLC-0100							
HS-0031	DSDO	NETWORK	SECONDARY REUSE PUMP 1 START/STOP	I-15	70-PLC-0100							
YL-0031A	DSDI	NETWORK	SECONDARY REUSE PUMP 1 READY IN REMOTE	I-15	70-PLC-0100							
YL-0031B	DSDI	NETWORK	SECONDARY REUSE PUMP 1 RUNNING	I-15	70-PLC-0100							

YA-0031A	DSDI	NETWORK	SECONDARY REUSE PUMP 1 FAIL	I-15	70-PLC-0100							
PAH-0031	DSDI	NETWORK	SECONDARY REUSE PUMP 1 HIGH DISCHARGE PRESSURE	I-15	70-PLC-0100							
TAH-0031	DSDI	NETWORK	SECONDARY REUSE PUMP 1 MOTOR HIGH TEMPERATURE	I-15	70-PLC-0100							
SI-0031	DSAI	NETWORK	SECONDARY REUSE PUMP 1 SPEED FEEDBACK	I-15	70-PLC-0100							
II-0031	DSAI	NETWORK	SECONDARY REUSE PUMP 1 MOTOR CURRENT	I-15	70-PLC-0100							
SK-0031	DSAO	NETWORK	SECONDARY REUSE PUMP 1 SPEED COMMAND	I-15	70-PLC-0100							
HS-0032	DSDO	NETWORK	SECONDARY REUSE PUMP 2 START/STOP	I-15	70-PLC-0100							
YL-0032A	DSDI	NETWORK	SECONDARY REUSE PUMP 2 READY IN REMOTE	I-15	70-PLC-0100							
YL-0032B	DSDI	NETWORK	SECONDARY REUSE PUMP 2 RUNNING	I-15	70-PLC-0100							
YA-0032A	DSDI	NETWORK	SECONDARY REUSE PUMP 2 FAIL	I-15	70-PLC-0100							
PAH-0032	DSDI	NETWORK	SECONDARY REUSE PUMP 2 HIGH DISCHARGE PRESSURE	I-15	70-PLC-0100							
TAH-0032	DSDI	NETWORK	SECONDARY REUSE PUMP 2 MOTOR HIGH TEMPERATURE	I-15	70-PLC-0100							
SI-0032	DSAI	NETWORK	SECONDARY REUSE PUMP 2 SPEED FEEDBACK	I-15	70-PLC-0100							
II-0032	DSAI	NETWORK	SECONDARY REUSE PUMP 2 MOTOR CURRENT	I-15	70-PLC-0100							
SK-0032	DSAO	NETWORK	SECONDARY REUSE PUMP 2 SPEED COMMAND	I-15	70-PLC-0100							
HS-0033	DSDO	NETWORK	SECONDARY REUSE PUMP 3 START/STOP	I-15	70-PLC-0100							
YL-0033A	DSDI	NETWORK	SECONDARY REUSE PUMP 3 READY IN REMOTE	I-15	70-PLC-0100							
YL-0033B	DSDI	NETWORK	SECONDARY REUSE PUMP 3 RUNNING	I-15	70-PLC-0100							
YA-0033A	DSDI	NETWORK	SECONDARY REUSE PUMP 3 FAIL	I-15	70-PLC-0100							
PAH-0033	DSDI	NETWORK	SECONDARY REUSE PUMP 3 HIGH DISCHARGE PRESSURE	I-15	70-PLC-0100							
TAH-0033	DSDI	NETWORK	SECONDARY REUSE PUMP 3 MOTOR HIGH TEMPERATURE	I-15	70-PLC-0100							
SI-0033	DSAI	NETWORK	SECONDARY REUSE PUMP 3 SPEED FEEDBACK	I-15	70-PLC-0100							
II-0033	DSAI	NETWORK	SECONDARY REUSE PUMP 3 MOTOR CURRENT	I-15	70-PLC-0100							
SK-0033	DSAO	NETWORK	SECONDARY REUSE PUMP 3 SPEED COMMAND	I-15	70-PLC-0100							
HS-0034	DSDO	NETWORK	SECONDARY REUSE PUMP 4 START/STOP	I-15	70-PLC-0100							
YL-0034A	DSDI	NETWORK	SECONDARY REUSE PUMP 4 READY IN REMOTE	I-15	70-PLC-0100							
YL-0034B	DSDI	NETWORK	SECONDARY REUSE PUMP 4 RUNNING	I-15	70-PLC-0100							
YA-0034A	DSDI	NETWORK	SECONDARY REUSE PUMP 4 FAIL	I-15	70-PLC-0100							
PAH-0034	DSDI	NETWORK	SECONDARY REUSE PUMP 4 HIGH DISCHARGE PRESSURE	I-15	70-PLC-0100							
TAH-0034	DSDI	NETWORK	SECONDARY REUSE PUMP 4 MOTOR HIGH TEMPERATURE	I-15	70-PLC-0100							
SI-0034	DSAI	NETWORK	SECONDARY REUSE PUMP 4 SPEED FEEDBACK	I-15	70-PLC-0100							
II-0034	DSAI	NETWORK	SECONDARY REUSE PUMP 4 MOTOR CURRENT	I-15	70-PLC-0100							
SK-0034	DSAO	NETWORK	SECONDARY REUSE PUMP 4 SPEED COMMAND	I-15	70-PLC-0100							
HS-0041	DSDO	NETWORK	EFFLUENT RETURN PUMP 1 START/STOP	I-16	70-PLC-0100							
YL-0041A	DSDI	NETWORK	EFFLUENT RETURN PUMP 1 READY IN REMOTE	I-16	70-PLC-0100							
YL-0041B	DSDI	NETWORK	EFFLUENT RETURN PUMP 1 RUNNING	I-16	70-PLC-0100							
YA-0041A	DSDI	NETWORK	EFFLUENT RETURN PUMP 1 FAIL	I-16	70-PLC-0100							
PAH-0041	DSDI	NETWORK	EFFLUENT RETURN PUMP 1 HIGH DISCHARGE PRESSURE	I-16	70-PLC-0100							
TAH-0041	DSDI	NETWORK	EFFLUENT RETURN PUMP 1 MOTOR HIGH TEMPERATURE	I-16	70-PLC-0100							
SI-0041	DSAI	NETWORK	EFFLUENT RETURN PUMP 1 SPEED FEEDBACK	I-16	70-PLC-0100							
II-0041	DSAI	NETWORK	EFFLUENT RETURN PUMP 1 MOTOR CURRENT	I-16	70-PLC-0100							
SK-0041	DSAO	NETWORK	EFFLUENT RETURN PUMP 1 SPEED COMMAND	I-16	70-PLC-0100							
HS-0042	DSDO	NETWORK	EFFLUENT RETURN PUMP 2 START/STOP	I-16	70-PLC-0100							
YL-0042A	DSDI	NETWORK	EFFLUENT RETURN PUMP 2 READY IN REMOTE	I-16	70-PLC-0100							
YL-0042B	DSDI	NETWORK	EFFLUENT RETURN PUMP 2 RUNNING	I-16	70-PLC-0100							
YA-0042A	DSDI	NETWORK	EFFLUENT RETURN PUMP 2 FAIL	I-16	70-PLC-0100							
PAH-0042	DSDI	NETWORK	EFFLUENT RETURN PUMP 2 HIGH DISCHARGE PRESSURE	I-16	70-PLC-0100							
TAH-0042	DSDI	NETWORK	EFFLUENT RETURN PUMP 2 MOTOR HIGH TEMPERATURE	I-16	70-PLC-0100							
SI-0042	DSAI	NETWORK	EFFLUENT RETURN PUMP 2 SPEED FEEDBACK	I-16	70-PLC-0100							
II-0042	DSAI	NETWORK	EFFLUENT RETURN PUMP 2 MOTOR CURRENT	I-16	70-PLC-0100							
SK-0042	DSAO	NETWORK	EFFLUENT RETURN PUMP 2 SPEED COMMAND	I-16	70-PLC-0100							
HS-0043	DSDO	NETWORK	EFFLUENT RETURN PUMP 3 START/STOP	I-16	70-PLC-0100							
YL-0043A	DSDI	NETWORK	EFFLUENT RETURN PUMP 3 READY IN REMOTE	I-16	70-PLC-0100							
YL-0043B	DSDI	NETWORK	EFFLUENT RETURN PUMP 3 RUNNING	I-16	70-PLC-0100							
YA-0043A	DSDI	NETWORK	EFFLUENT RETURN PUMP 3 FAIL	I-16	70-PLC-0100							
PAH-0043	DSDI	NETWORK	EFFLUENT RETURN PUMP 3 HIGH DISCHARGE PRESSURE	I-16	70-PLC-0100							
TAH-0043	DSDI	NETWORK	EFFLUENT RETURN PUMP 3 MOTOR HIGH TEMPERATURE	I-16	70-PLC-0100							
SI-0043	DSAI	NETWORK	EFFLUENT RETURN PUMP 3 SPEED FEEDBACK	I-16	70-PLC-0100							
II-0043	DSAI	NETWORK	EFFLUENT RETURN PUMP 3 MOTOR CURRENT	I-16	70-PLC-0100							
SK-0043	DSAO	NETWORK	EFFLUENT RETURN PUMP 3 SPEED COMMAND	I-16	70-PLC-0100							

DIVISION 41
MATERIAL PROCESS HANDLING EQUIPMENT

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SECTION 41 05 02
IDENTIFICATION FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide identification for all exposed piping and valves, in accordance with the requirements of the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ANSI A13.1	Scheme for the Identification of Piping Systems

1.3 CONTRACTOR SUBMITTALS

A. All submittals shall be in strict accordance with the requirements of Section 01 33 20 - Contractor Submittals.

B. Submit samples of all types of identification devices to be used in the Work.

C. Submit a list of suggested wording for all valve tags prior to fabrication.

PART 2 - PRODUCTS

2.1 IDENTIFICATION OF PIPING

A. Identification of all exposed pipe shall be accomplished in accordance with the Owner's standard, and where no standard exists, in accordance with the following: by color-coding top coat color and by lettering as specified in Part 3, herein, and in Section 09 90 00 – Paintings and Coatings. Identification of all exposed pipe shall be accomplished in accordance with the standards of color coding contained within this specification. The coating system for pipe color coding topcoat shall conform to Section 09 90 00 – Coatings and Painting Where it is not possible to color code a pipe using a coating, color bands shall be used.

B. Each pipe identification shall consist of color-coded coating, a printed label identifying the name of the pipe, and a flow arrow to indicate direction of flow in the pipe. All labels shall be preprinted on pressure-sensitive adhesive-backed vinyl cloth or plastic tape. Arrows shall be die-cut of the same type of material as the labels.

C. Letter sizes and colors for lettering, arrows, and background shall conform to ANSI A13.1.

D. Preprinted identification devices shall be as manufactured by W.H. Brady Co.; Seton Nameplate Corp.; or equal.

2.2 EXISTING IDENTIFICATION SYSTEMS

A. In installations where existing piping identification systems have been established, continue to use the existing system. Where existing identification systems are incomplete, utilize the existing system as far as practical and supplement with the specified system. The objective is to fully identify all new piping, valves, and appurtenances to the level specified herein.

2.3 IDENTIFICATION OF VALVES AND SHORT PIPE LENGTHS

A. Identifying devices for valves and the sections of pipe that are too short to be identified with color bands, lettered labels, and arrows shall be identified with metal or plastic tags as indicated.

B. Metal tags shall be of stainless steel with embossed lettering. Plastic tags shall be of solid black plastic laminate with white embossed letters. All tags shall be designed to be firmly attached to the valves or short pipes or to the structure immediately adjacent to such valves or short pipes.

PART 3 - EXECUTION

3.1 GENERAL

A. All labels and identification tags shall be installed in accordance with the manufacturer's printed instructions, and shall be neat and uniform in appearance. All such tags or labels shall be readily visible from all normal working locations.

3.2 VALVE TAGS

A. Valve tags shall be permanently attached to the valve or structure by means of 2 stainless steel bolts or screws.

B. The wording on the valve tags shall describe the exact function of each valve, e.g., "HWR-BALANCING," "CLS THROTTLING", "RAS-PUMP SHUT-OFF," etc.

3.3 PIPE IDENTIFICATION

A. Each pipe shall be identified at intervals of 20 feet, and at least one time in each room. Piping shall also be identified at a point approximately within 2 feet of all turns, ells, valves, and on the upstream side of all distribution fittings or branches. Sections of pipe that are too short to be identified with color bands, lettered labels, and directional arrows shall be tagged and identified similar to valves.

B. Pipe identification shall consist of these elements, i.e., color coating, a lettered label, and a directional label.

3.4 IDENTIFICATION SCHEDULE

A. Application of identifying devices shall conform to the following color codes where no colors are indicated in the Owner’s standard.

Fluid Abbreviation	Function and Identification	Identification Color
BWW	Filter backwash waste	light brown
CL	Chlorine (gas or liquid state)	yellow
CLS	Chlorine solution	orange
EFR	Effluent return	light purple
IRR	Irrigation water	purple
NG	Natural gas	yellow
NPW	Non-potable water	purple
PD	Plant drain	green
PW	Potable water	blue
SA	Sample lines	light blue
SPD	Sump pump discharge	gray
SR	Secondary Reuse	purple
SS	Sanitary sewer	green

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DIVISION 43
GAS, LIQUID, AND STORAGE

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SECTION 43 10 63
SMALL POLYETHYLENE PRESSURE TUBING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide HDPE tubing, complete and in place, in accordance with the Contract Documents.

B. HDPE tube shall be used as a sample line to the turbidimeters in accordance with the requirements of this section.

1.2 ASTM applicable standards:

ASTM D3350 - Polyethylene Plastic Pipe Fittings Method

ASTM D3035 - Polyethylene (PE) Plastic Pipe Based on Controlled O.D.

ASTM D1248 - Specification for Polyethylene Plastic Molding and Extrusion Material

ASTM D2239 - Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter

ASTM D2447 - Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on O.D.

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings of pipe, fittings, and appurtenances, in accordance with Section 01 33 20 – Submittal Procedures.

B. Certifications: Furnish a certified affidavit of compliance for tube and other products or materials furnished under this Section:
1. Hydrostatic proof test reports.
2. Sustained pressure test reports.
3. Burst strength test reports.

C. Expenses incurred in making samples for certification of tests shall be borne by the CONTRACTOR as part of the WORK.

1.4 QUALITY ASSURANCE

A. Each manufacturer shall have an approved in-house QA/QC program for compliance to the testing specifications and requirements of ASTM D3350 for both tube and fittings.

B. Inspection: Tube shall be subject to inspection at the place of manufacture in accordance with the provisions of the referenced standards as supplemented by the requirements herein. The CONTRACTOR shall notify the ENGINEER in writing of the manufacturing start date not less than 14 calendar days prior to the start of any phase of manufacture.

C. During manufacture of the tube, the ENGINEER shall be given access to areas where manufacturing is in process confirm compliance with the Specifications.

D. Tests: Except as modified herein, materials used in the manufacture of the tube shall be tested in accordance with the requirements of this Section and in the referenced standards, as applicable.

E. The CONTRACTOR shall perform said material tests in accordance with the requirements of the Contract Documents. The ENGINEER shall have the right to witness testing conducted by the CONTRACTOR, provided that the CONTRACTOR's schedule will not be delayed for the convenience of the ENGINEER.

F. In addition to those tests specifically required, the ENGINEER may request additional samples of any material for testing by the OWNER. The additional samples shall be furnished as part of the WORK.

PART 2 -- PRODUCTS

2.1 GENERAL

A. HDPE tubing and fittings shall be suitable for use with sample water per the Contract Documents.

B. All HDPE tubing, fittings and fusion equipment shall be from one supplier. Tubing and fittings shall be manufactured by an ISO 9001 certified manufacturer.

2.2 TUBING MATERIAL

A. Wall thickness shall be SDR 11 minimum. All tubing, fittings and fabrications shall be suitable for 100 psi pressure testing.

B. The following criteria are to be met by the actual tubing material and base resin:
   1. Density class 4 of 0.947 – 0.955 gm/cc.
   2. SCG (slow crack growth) cell class 7 or PENT value of 500 hours.
   3. HDS (hydrostatic design stress) of 1000 psi

C. Resin materials shall be rated as PE 4710 per the Plastic Pipe Institute. Tubing shall be made from PE4710 resins exhibiting a cell classification of PE 445574C/E as defined in ASTM D3350, with a hydrostatic design basis of 1600 psi for water at 73 degrees F. The resin shall be listed by the PPI (Plastic Pipe Institute) in its pipe-grade registry Technical Report (TR) 4 – PPI Listing of Hydrostatic Design Basis (HDB), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe (latest edition).

D. The tubing shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.

2.3 FITTINGS

A. All HDPE fittings shall be from the same PE4710 resin as the tubing. If required by the ENGINEER, a letter of certification shall be provided by the supplier to indicate that the same resin is used for the tubing and fittings.

B. All fittings shall be one-piece molded type fittings. Molded fittings shall match the tubing SDR, manufactured in accordance with ASTM D 3261.

2.4 JOINTS

A. Typical joints shall be thermally butt-fused. The procedure shall follow the manufacturer's instructions. If instructions are not available, the contractor shall follow, at a minimum, the recommendations PPI (Plastic Pipe Institute) Technical Report (TR) 33 – Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe (latest edition).

B. Electro-fusion fittings (including couplings, elbows, bends, tees, etc.) shall be accessible and shall only be allowed in chemical pull boxes, chemical trenches, chemical containments areas, or where approved by the ENGINEER. In addition, electro-fusion fittings will only be considered for approval where thermally butt-fused joints and fittings cannot be used. To help minimize the need for electro-fusion fittings, limited access heat fusion machines shall be used where the standard heat fusion machines cannot be reasonably used. Electro-fusion fittings shall be SDR 11 and shall be installed with electronic monitoring and control. When used, electro-fusion fittings shall be installed in accordance with the manufacturer's instructions and recommendations. The outside of the tubing shall be shaved to clean the surface of the tubing prior to the installation of the electro-fusion fittings. The outside of the tubing shall be kept clean after shaving to help ensure proper fusion. A data-logger shall be used to monitor and log the data for every electro-fusion joint.

2.5 MARKINGS

A. The standard markings printed on tubes shall consist of:
   1. nominal size and OD base
   2. material code (e.g. PE4710)
   3. dimension ratio
   4. pressure class
   5. current AWWA C906 (if applicable)
   6. ASTM F714 (if applicable)
   7. production date (day, month, & year).

2.6 MANUFACTURERS, OR EQUAL

A. HDPE tubing and fittings shall be manufactured by:
   1. Performance Pipe by Chevron-Phillips
   2. Poly Pipe Industries, Inc.
   3. JM Manufacturing Company, Inc.

B. Molded HDPE fittings shall be manufactured by:
   1. Performance Pipe by Chevron-Phillips
   2. Central Plastics Company

3. Industrial Pipe Fittings

PART 3 -- EXECUTION

3.1 MANUFACTURER'S SERVICE REPRESENTATIVE

A. Installation and Start-up Assistance
   1. Furnish service and instruction assistance by the manufacturer's engineering representative for each equipment unit, during the following period:
      a. One day during installation, unless indicated otherwise in the feed equipment specification Section.
      b. One day during startup, unless indicated otherwise in the feed equipment specification Section.

3.2 INSTRUCTION OF OWNER'S PERSONNEL

A. The training representative of the manufacturing shall be present at the Site to furnish the services required by Section 01 91 14 – Equipment Testing and Start-Up.

B. The manufacturer shall furnish the services of a factory trained representative to train the OWNER's personnel per Section 01 91 14.

3.3 GENERAL

A. Laying, jointing, and testing for defects and for leakage shall be performed in the presence of the ENGINEER and shall be subject to approval before acceptance. All material found to be defective will be rejected and the CONTRACTOR shall promptly remove such materials from the Site.

B. Installation shall conform to AWWA M55, instructions furnished by the tube manufacturer, and to the supplementary requirements or modifications herein. Wherever the provisions of this Section and the aforementioned requirements are in conflict, the more stringent provision shall apply.

C. Installation of HDPE piping and fittings shall be performed by fully trained personnel in accordance with the manufacturer's instructions and recommendations. Installers of HDPE tubing and fittings shall have valid certification cards that are less than 12 months old provided by the manufacturer or supplier of the heat fusion and electro-fusion equipment indicating that they have successfully completed training courses for all types of HDPE joints and fittings to be used.

D. The installation crew shall be supervised at all times by one or more "Field Supervisors", who shall be provided by the manufacturer or supplier of the heat fusion and electro-fusion equipment. The Field Supervisors shall be competent and fully trained in installation, heat fusion, and electro-fusion procedures necessary for successful installation of HDPE piping and all methods used for joints and fittings.

3.4 HANDLING AND STORAGE

A. Handling: Tube, fittings, and accessories shall be carefully inspected before and after installation and those found defective will be rejected. Tube and fittings shall be free from fins and burrs. Before placing in position, clean tube, fittings, and accessories, and maintain them in a clean condition. Proper methods shall be used for lowering sections of tube into trenches. Under no circumstances shall tube, fittings, or any other material be dropped or dumped into trenches.

B. Storage: Tube shall be stored, if possible, at the Site in unit packages provided by the manufacturer. Caution should be exercised to avoid compression damage or deformation to the tube. Tube shall be stored in such a way as to prevent sagging or bending, and it shall be protected from exposure to direct sunlight by covering with an opaque material that allows adequate air circulation above and around the tube. Gaskets shall be stored in a cool, dark place out of the direct rays of the sun, preferably in original cartons.

3.5 JOINING

A. Prior to installation of any tube, the manufacturer shall provide training in the recommended butt fusion and saddle fusion procedures, testing procedures, and any other installation methods required by the WORK. Training shall include the CONTRACTOR's installation personnel, an OWNER's representative, the ENGINEER's representative, and any other personnel chosen by the OWNER. The CONTRACTOR shall record the names of trained personnel.

B. On every day that butt fusion joints are to be made, the first fusion of the day shall be a test. The test fusion shall be allowed to cool completely, then fusion test straps shall be cut out. Test strap length shall be 12-inches (min) or 30 times the wall thickness with the fused area in the center and width shall be 1-inch (min) or 1.5 times the wall thickness. The CONTRACTOR shall bend the test strap until the ends of the strap touch. If the test strap fails at the joint, the CONTRACTOR shall perform a new test to be cooled completely and bent as before. The CONTRACTOR shall not commence installation of tube until a test fusion has passed the bent strap test.

C. The fusion machine used in the joining of the tube shall incorporate a data logging device that records information related to each individual joint for the construction of the entire tubeline. The recorded information shall include at least the date and time of the fusion, the employee ID of the machine operator, the machine ID, the machine model, the piston area, tube material, tube size, the interfacial pressures (including heat, soak, fuse, cool), recommended gauge pressures (including heat, soak, fuse, cool), drag pressure, data logger probe temperature, and the external probe temperature.

3.6 INSTALLATION

A. Tube shall be cut by means of saws, power driven abrasive wheels, pipe cutters, or other manufacturer recommended methods that will produce a clean, square cut.

B. Joints shall be installed according to manufacturer's recommendations. Containment piping shall be kept free of water and dirt and debris. The maximum combined deflection at any coupling shall be in accordance with the manufacturer's recommendations.

3.7 SUPPORTS AND ANCHORS

A. HDPE carrier tube shall be supported in accordance with Section 40 05 07 – Pipe Supports.

3.8 FIELD TESTING

A. All finished installations shall be carefully inspected for proper supports, anchoring, interferences, and damage to tubing, fittings, and coating. Any damage shall be repaired to the satisfaction of the ENGINEER. Leaks shall be repaired to the satisfaction of the ENGINEER, and the system shall be re-tested until no leaks are

END OF SECTION

SECTION 43 10 65
DOUBLE CONTAINMENT PIPING

PART 1 GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide a Schedule 80 chlorinated polyvinyl chloride (CPVC)/Schedule 40 polyvinyl chloride (PVC) double containment piping system, complete, and operable in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Section 01 33 20 –Submittal Procedures

B. Section 01 25 10 – Products, Materials, Equipment and Substitutions

C. Section 09 90 00 – Painting and Coating

D. Section 40 05 00 – Piping, General

E. Section 41 05 02 – Identification for Piping and Equipment

F. Section 40 05 07 – Pipe Supports

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 20 – Submittal Procedures and Section 40 05 00 – Piping, General.

B. Shop Drawings:
1. Pipe fabrications (including supporting devices, method of attachment, spacing, expansion loops, etc.), prefabricated double containment fitting dimensions, starting and terminating connections, high point vent and low point drain details for the secondary containment, valves, and accessories. Submit joint details, methods and location of supports, and other pertinent technical data for all piping to be provided.
2. Include a detailed design layout of the piping systems.

1.4 QUALIFICATIONS

A. Obtain the double containment piping system from a single supplier to ensure single source responsibility.

B. Piping MANUFACTURER shall review and recommend all material selections, expansion loops, sizing and anchoring. Piping MANUFACTURER shall have a minimum of five (5) years of experience.

PART 2 PRODUCTS

2.1 DESCRIPTION OF SYSTEMS

A. The piping system shall be designed, fabricated and constructed to provide containment for the following chemical systems from 32°F to 120°F:
   1. Aluminum sulfate (48.5 percent) solution.
   2. Chlorine gas injected into utility water solution (1 mg/L).

2.2 DOUBLE CONTAINMENT PIPING

A. Each contained piping system shall consist of Schedule 80 CPVC primary piping system supported within a Schedule 40 PVC secondary containment housing. Each system shall be provided with suitable drains and vents and be designed to provide complete drainage of both the primary and secondary containment piping.

B. The primary pipe and fittings shall be manufactured from Schedule 80 CPVC materials as listed by ASTM and ANSI.

C. The secondary containment pipe and fittings shall be manufactured from Schedule 40 PVC materials as listed by ASTM and ANSI.

D. CPVC pipe shall be in accordance with ASTM F 441 - Chlorinated Poly (Vinyl Chloride) (CPVC), Plastic Pipe, Schedules 40, and 80, from all new compounds, meeting the requirements of Class 23447 per ASTM D 1784 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (PVC) Compounds. CPVC pipe shall be Schedule 80 pipe unless otherwise indicated. PVC pipe shall be made from new rigid unplasticized polyvinyl chloride and shall be normal impact Type 1, Grade 1, Cell Classification 12454, ASTM D1784, Schedule 40. Other unlisted components that are intended for use as pressure retaining components shall have sufficient thickness and reinforcement so as to be able to maintain the same pressure ratings as the equivalent Schedule 80 CPVC pipe (for carrier pipe) or Schedule 40 PVC (for containment).

E. Interstitial supporting devices used to center and support the primary piping within the secondary containment piping shall be manufactured from PVC or CPVC spider clips or C-Type, according to ASTM and ANSI. Supporting devices shall allow continuous drainage in the annular space to the drain points.

F. Fittings shall be pre-assembled and pre-tested by the MANUFACTURER.

G. At all piping low points, or at a minimum spacing of 250 feet, a clear drip leg and ball valve for draining with threaded hose connection shall be provided.

H. CPVC Pipe joints shall be solvent welded with solvent cement in accordance with ASTM F 493, and with primer in accordance with ASTM F 656. The solvent cement shall be manufactured by IPS Corporation or equal and shall be compatible with the chemical service.

I. PVC piping joint shall be solvent welded with solvent cement in accordance with ASTM D2654, and with primer in accordance with ASTM F 656. The solvent cement shall be manufactured by IPS Corporation or equal and shall be compatible with the chemical service.

J. Manufacturer, or Equal
1. Asahi/America
2. IPEX
3. GF Piping Systems
4. Guardian, a Division of NIBCO
5. IPS Corporation
6. Spears Manufacturing Company

PART 3 EXECUTION

3.1 DOUBLE CONTAINMENT PIPING INSTALLATION

A. General: CPVC/PVC pipes shall be installed in a neat and workmanlike manner, properly aligned, and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipes shall afford maximum headroom and access to equipment, and where necessary, all piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. Installations shall be acceptable to the ENGINEER.

B. Obtain the assistance of the pipe MANUFACTURER'S field representative to instruct the pipe fitters in the correct installation and support of CPVC/PVC piping.

C. Supports and Anchors: Piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 40 05 07 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipes shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences.

D. Valves and Unions: Unless otherwise indicated, all connections to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

E. CONTRACTOR personnel that will prepare solvent cemented joints shall be qualified for such bonding practices according to the bonding qualification procedures described in ASME B 31.3, Chapter VII for bonding of plastic piping. The bonding qualification procedure shall be that as written and furnished by the MANUFACTURER.

3.2 EXPOSED PIPE COATING

A. Apply System NFS-4 per Section 09 90 00 – Protective Coatings. Unless permanently welded or glued, fittings, connections, unions, and valves shall not be coated.

3.3 PIPE PREPARATION

A. Prior to installation, each pipe length shall be carefully inspected, flushed clean of any debris or dust, and be straightened, if not true. Pipe fittings shall be cleaned before assembly.

3.4 PIPE JOINTS

A. Solvent-Welded Joints: Solvent-welded joints shall be made with fresh primer and solvent cement on clean, dry pipe ends. The primer and cement cans shall be kept closed at all times and the joints shall be made up at the recommended ambient temperatures, to the pipe MANUFACTURER'S written recommendations. Pipe ends shall be inserted to the full depth of the socket.

3.5 INSPECTION AND FIELD TESTING

A. Inspection: The finished installation shall be carefully inspected for proper joints and sufficient supports, anchoring, interferences, and damage to pipe, fittings, and coating. Damage shall be repaired to the satisfaction of the ENGINEER.

B. Upon completion of installation, the primary piping system shall be flushed clean. Check the operation of valves, and appurtenances.

C. Upon completion of installation but prior to enclosure or burying, the primary piping system shall be pressure tested as required in the Piping Schedule, for a period of not less than one (1) hour, without exceeding the tolerances listed in the Piping Schedule. Where no pressure is indicated, the pipes shall be subject to 1-1/2 times the maximum working pressure. Furnish all test equipment, labor, materials, and devices at no extra cost to the OWNER.

1. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. All fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines be plugged or capped as required during the testing procedures.

2. Leaks shall be repaired to the satisfaction of the ENGINEER, and the system shall be retested until no leaks are found.

D. The secondary containment piping system shall be pneumatically tested at 10 psi at a minimum duration of 2-1/2 hours. The external joints should be soaped and visually inspected for leaks. It is imperative that a working pressure regulator be used during the pneumatic test to ensure that over-pressurization of the CPVC

beyond 10 psi cannot occur. Also, precautions should be taken to protect against the hazards of a possible fracture of CPVC under compressed gas.

E. The testing of the primary and secondary piping shall be done in strict accordance with the recommendations of the MANUFACTURER.

F. The annular space shall be purged of moisture containing air by replacing the volume of air with clean, dry nitrogen or minus 20 degrees F dew point air. The piping containment system shall be sealed upon completion of purge.

3.6 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. Furnish the services of a qualified technical representative of the double containment piping MANUFACTURER to instruct the CONTRACTOR'S personnel as to the proper installation of each system. The representative shall observe the installation of the systems to ensure proper compliance with the recommended installation procedures. Representatives from the MANUFACTURER shall also be present for the testing of the systems. A minimum of three (3) Days shall be furnished by the MANUFACTURER for on-site services related to installation and testing of the systems.

B. The MANUFACTURER'S representative shall provide one (1) day of training of the OWNER'S personnel for the double containment piping.

C. Any additional time required to achieve successful installation and operation shall be at no additional cost to the OWNER. The MANUFACTURER'S representative shall sign in and out at the office of the ENGINEER for each day at the Site.

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SECTION 43 20 10
PUMPS, GENERAL

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall provide all pumps and pumping appurtenances, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all pumps and pumping equipment except where otherwise indicated in the Contract Documents.

C. Unit Responsibility: A single manufacturer shall be made responsible for furnishing the Work and for coordination of design, assembly, testing, and installation of the Work of each pump Section; however, the Contractor shall be responsible to the Owner for compliance with the requirements of each pump Section. Unless otherwise indicated, the single Manufacturer shall be the Manufacturer of the pump.

D. Single Manufacturer: Where two or more pump systems of the same type or size are required, the pumps shall all be produced by the same Manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be furnished in accordance with Section 01 33 20 – Submittal Procedures.

B. Shop Drawings: Shop drawings shall contain the following information:
   1. Pump name, identification number, and specification Section number.
   2. Performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump. The equipment Manufacturer shall indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the design flow conditions and the maximum and minimum flow conditions. A family of performance curves at intervals of 100 rpm from minimum speed to maximum speed shall be provided for each centrifugal pump equipped with a variable frequency drive.
   3. The Contractor shall require the Manufacturer to indicate on the performance curves the limits recommended for stable operation without surge, without cavitation, and without vibration (except vibration within specified allowable limits). The stable operating range shall be as wide as possible based on actual hydraulic and mechanical measurements taken during the factory performance tests of the pumps.
   4. Assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, part nomenclature, material list, outline dimensions, and shipping weights.
   5. Data, in accordance with Section 26 20 00 - Low-Voltage AC Induction Motors, for the electric motor proposed for each pump.
   6. Elevation of proposed Local Control Panel showing panel-mounted devices, details of enclosure type, single line diagram of power distribution, and current draw of panel,

and list of all terminals required to receive inputs or to transmit outputs from the Local Control Panel.

7. Wiring diagram of field connections with identification of terminations between Local Control Panels, junction terminal boxes, and equipment items.
8. Complete electrical schematic diagram.

C. Operation and Maintenance Manual: The Manual shall contain the required information for each pump Section.

D. Spare Parts List: A Spare Parts List shall contain the required information for each pump Section.

E. Factory Test Data: Signed, dated, and certified factory test data for each pump system which requires factory testing, submitted before shipment of equipment.

F. Certifications
1. Manufacturer's certification of proper installation.
2. Contractor's certification of satisfactory field testing.

G. Structural Frequency Analysis: If the pumps are operating on VFD, perform and submit structural frequency analysis (Reed Critical Frequency) calculations showing that the design of the Pump, head shaft and bowls, have been engineered to push any critical frequency 20 percent above or below the specified operating range. Submit analysis signed and stamped by the professionally licensed engineer who performed the analysis work prior to fabrication of the pumps.

1.3 QUALITY ASSURANCE

A. Factory Testing: The following tests shall be conducted on each indicated pump system:
1. Motors: All motors of sizes 100 hp and larger shall be assembled, tested, and certified at the motor factory and the working clearances checked to insure that all parts are properly fitted. The tests shall be in accordance with ANSI/IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators, and ANSI/IEEE 115 - Test Procedure for Synchronous Machines, including heat run and efficiency tests. All computations shall be recorded and certified and dated copies of the test results shall be furnished.
2. Pump Systems: All centrifugal pump systems 10 HP and larger shall be tested at the pump factory in accordance with the Test Code for Centrifugal Pumps of the Standards of the Hydraulic Institute, Inc. HI Acceptance Grade 1B Standards shall apply. Tests shall be performed using the complete pump system to be furnished, with a manufacturer calibrated and certified motor. Structural Frequency Analysis shall be performed as noted in paragraph 1.2G.
3. Testing of prototype pump models will not be acceptable. The following minimum test data shall be submitted:
    a. Hydrostatic test data
    b. A minimum of five hydraulic test readings between shutoff head and 25 percent beyond the maximum indicated capacity, recorded on data sheets as defined by the Hydraulic Institute.
    c. Pump curves showing head, flow, bhp, efficiency, and NPSH requirements.

d. Certification that the pump horsepower demand did not exceed the rated motor hp beyond the 1.15 service rating at any point on the curve.

4. Factory Witnessed Tests: Not required.

B. Warranty: Unless otherwise specified, each pump shall be supplied with manufacturer's standard warranty of one (1) year from the Project's substantial completion.

C. ENGINEERED ANALYSIS: The pumping unit shall be deigned to safely operate free of resonant frequency. In order to ensure that neither harmful nor damaging vibrations occur to the pump structure at any speed within the specified operating range, the following analysis shall be required to be performed by a licensed Professional Engineer using finite element analysis (FEA) software:

1. Pump manufacturer shall perform a structural frequency analysis of the structural components utilizing a FEA method to ensure that no structural natural frequencies are excited to a degree that would cause measured vibration amplitudes at the top of the discharge head to exceed the requirements of ANSI/HI 9.6.4-2009. When modeling wells, or when deemed necessary by the experience of the manufacturer, the below ground structural components shall also be included in the analysis.

2. A report shall be provided with the submittal showing that the natural frequencies and mode shapes of the pump and motor have been considered in the design of the discharge head, and certify that the critical frequency is at least 20% above or below the operating range.

3. When significant modifications are required to lower the system's natural frequency, the pump structure's stresses and deflections shall also be reviewed. The design critical frequency shall be at least 20% above or below the operating range of the pump.

4. Manufacturer to provide documentation of the analysis ensuring that the specified requirements have been met, that the pump will operate free of resonance frequency vibration over its full operating range and speeds, and that documentation should be signed and stamped by the professionally licensed engineer who performed the analysis work.

PART 2 - PRODUCTS

2.1 GENERAL

A. Compliance with the requirements of the individual pump Sections may necessitate modifications to the Manufacturer's standard equipment.

B. Performance Curves: All centrifugal pumps shall have a continuously rising curve. In no case shall the required horsepower at any point on the performance curve exceed the rated horsepower of the motor or engine, or encroach on the service factor.

C. No cavitation shall be allowed in pumps operating within the stable operating range for the specified operating conditions. For the purposes of this provision, cavitation shall be

recognized and accepted as being present in a pumping unit if cavitation noise can be perceived either by the human ear or by acoustic instruments or devices. The presence or absence of cavitation noise shall be verified by the Owner during both the factory performance tests of the pumps and during operation of the pumps up to the end of the warranty period. To assist in revealing potential cavitation during the factory performance tests, in addition to all other required tests, the Manufacturer shall force the pumps to operate at the specified minimum net positive suction head available for each of the following conditions: minimum flow rate, design flow rate and head, and maximum flow rate.

D. All components of each pump system provided under the pump Sections shall be entirely compatible. Each unit of pumping equipment shall incorporate all basic mechanisms, couplings, electric motors, variable frequency controls if required, necessary mountings, and appurtenances.

2.2 MATERIALS OF CONSTRUCTION

A. All materials shall be suitable for the intended application; materials not specified shall be high-grade, standard commercial quality, free from all defects and imperfection that might affect the serviceability of the product for the purpose for which it is intended, and shall conform to the following requirements:

1. Cast iron pump casings and bowls shall be of austenitic ductile iron, conforming to ASTM A 439 - Specification for Austenitic Ductile Iron Castings, or equal.
2. Bronze pump impellers shall conform to ASTM B 62 - Specification for Composition Bronze or Ounce Metal Castings, or B 584 - Specification for Copper Alloy Sand Castings for General Applications, where dezincification does not exist.
3. Stainless steel pump shafts shall be Type 416. Miscellaneous stainless steel parts shall be of Type 416.
4. All anchor bolts, nuts, and washers that are not buried or submerged shall be zinc plated and painted to match steel piping, unless otherwise specified in individual pump Sections. Buried or submerged bolts, nuts, and washers shall be 316 stainless steel in accordance with Section 05 50 00 – Metal Fabrications.

2.3 PUMP COMPONENTS

A. Flanges: Suction and discharge flanges shall conform to ANSI/ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800 or B16.5 - Pipe Flanges and Flanged Fittings Dimensions or B16.9; rated for 1.2 times pump shut off head at 150 Degrees F.

B. Lubrication: Vertical pump shall be product water-lubricated.

C. Handholes: Handholes on pump casings shall be shaped to follow the contours of the casing to avoid any obstructions in the water passage.

D. Vortex Suppressors: Vertical pumps shall be provided with vortex suppressors. Design suction bells and provide 316 SST strainers and vortex suppresser to have a flow area of at least 4 times the suction pipe area

E. Drains: All gland seals, air valves, cooling water drains, and drains from variable frequency drive equipment shall be piped to the nearest floor sink, or drain, with PVC pipe or copper tube, properly supported with brackets.

F. Grease Lubrication: All vertical propeller, mixed-flow, and turbine pumps shall have permanently greased-lubed bottom bearings.

G. Mechanical Seals: Mechanical seals shall be product water-flushed. Mechanical seals shall be as manufactured by the following, or equal:

Type	Manufacturer
Wastewater Pumps	Double seals: John Crane Type L Double; Borg-Warner Type L Double; Chesterton
Abrasives, Grit, or Lime Slurry Pumps	Double seals: John Crane Type I (hard faces); Borg-Warner Type L (hard faces); Chesterton
Chemicals or Corrosive Liquid Pumps	Single seals: John Crane Type 8-1, 9; Borg-Warner Type Q, QB; Chesterton
Water Pumps Hot and Cold	Single seals: John Crane, Type I, 21; Borg-Warner Type L; Chesterton

H. Where indicated, a buffer fluid must be circulated a minimum 20 psi above discharge pressure, or as required by the Manufacturer, in order to maintain reliable seal performance.

I. Mechanical seals for all services other than chemicals and corrosives shall be equipped with non-clogging, single coil springs and non-sliding, internal, secondary elastomers. Metal parts shall be Type 416 stainless steel, Alloy 20, or Hastelloy B or C.

2.4 PUMP APPURTENANCES

A. Nameplates: Each pump shall be equipped with a stainless steel nameplate indicating serial numbers, rated head and flow, impeller size, pump speed, and Manufacturer's name and model number. Dimension and flow information shall be in English units.

B. Solenoid Valves: The pump Manufacturer shall provide solenoid valves on the water or oil lubrication lines and on all cooling water lines. Solenoid valve electrical ratings shall be compatible with the motor control voltage.

C. Gauges: all pumps (except sample pumps, sump pumps, and hot water circulating pumps) shall be equipped with pressure gauges installed at pump discharge lines. Pump suction lines shall be provided with compound gauges. Gauges shall be located in a representative location, where not subject to shock or vibrations, in order to achieve true and accurate readings.

1. Where subject to shock or vibrations, the gauges shall be wall-mounted or attached to galvanized channel floor stands and connected by means of flexible connectors.
2. Pressure and compound gauges shall be provided in accordance with Section 40 73 13- Pressure Gauges.

PART 3 - EXECUTION

3.1 SERVICES OF MANUFACTURER

A. Inspection, Startup, and Field Adjustment: Where required by the individual pump Sections, an authorized service representative of the Manufacturer shall visit the site for the number of days indicated in those Sections to witness the following and to certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation.
   1. Installation of the equipment.
   2. Inspection, checking, and adjusting the equipment.
   3. Startup and field testing for proper operation.
   4. Performing field adjustments to ensure that the equipment installation and operation comply with the specified requirements.

B. Instruction of the Owner's Personnel
   1. Where required by the individual pump Sections, an authorized training representative of the Manufacturer shall visit the site for the number of days indicated in those Sections to instruct the Owner's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment. Instruction shall be specific to the models of equipment provided.
   2. The representative shall have at least two years' experience in training. A resume for the representative shall be submitted.
   3. Training shall be scheduled a minimum of three weeks in advance of the first session.
   4. Proposed training material and a detailed outline of each lesson shall be submitted for review. Comments shall be incorporated into the material.
   5. The training materials shall remain with the trainees.
   6. The Owner may videotape the training for later use with the Owner personnel.

3.2 INSTALLATION

A. General: Pumping equipment shall be installed in accordance with the Manufacturer's written recommendations.

B. Alignment: All equipment shall be field tested to verify proper alignment, operation as specified, and freedom from binding, scraping, vibration, shaft runout, or other defects. Pump drive shafts shall be measured just prior to assembly to ensure correct alignment without forcing. Equipment shall be secure in position and neat in appearance.

C. Lubricants: The Contractor shall provide the necessary oil and grease for initial operation.

3.3 PROTECTIVE COATING

A. Materials and equipment shall be coated as required in Section 09 90 00 – Painting and Coating and as indicted in each individual pump specification section.

3.4 FIELD TESTS

A. Each pump system shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, cavitation, or overheating of bearings.

B. The following field testing shall be conducted:
   1. Startup, check, and operate the pump system during start up, shutdown and over its entire speed range. Verify compliance with performance requirements. Vibration shall be within the amplitude limits recommended by the Hydraulic Institute Standards at a minimum of five pumping conditions defined by the Engineer.
   2. Obtain concurrent readings of motor voltage, amperage, pump suction head, and pump discharge head for at least four pumping conditions at each pump rotational speed and flow rate. Check each power lead to the motor for proper current balance.
   3. Determine bearing temperatures by contact type thermometer. A run time of at least 20 minutes shall precede this test unless insufficient liquid volume is available.
   4. Electrical and instrumentation tests shall conform to the requirements of the Sections under which that equipment is indicated.
   5. Acceptance: In the event of failure of any pump to meet any of the indicated requirements, the CONTRACTOR shall make all necessary modifications, repairs, or replacements to conform to the requirements of the Contract Documents and the pump shall be re-tested at no additional cost to the OWNER until satisfactory results are achieved

C. Field testing will be witnessed by the Engineer. The Contractor shall furnish 10 days advance notice of field testing.

D. In the event any pumping system fails to meet the test requirements, it shall be modified and retested as above at no additional cost to the owner until it satisfies the requirements.

E. After each pumping system has satisfied the requirements, the Contractor shall certify in writing that it has been satisfactorily tested and that all final adjustments have been made. Certification shall include the date of the field tests, a listing of all persons present during the tests, and the test data.

F. The Contractor shall bear all costs of field tests, including related services of the Manufacturer's representative, except for power and water which the Owner will bear. If available, the Owner’s operating personnel will provide assistance in field testing. Manufacturer shall provide testing equipment as required to complete the specified testing

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SECTION 43 23 31
CENTRIFUGAL BOOSTER PUMPS

PART 1 -- GENERAL

1.1 SUMMARY

A. Section Includes: Centrifugal in-line booster pumps for use for the chlorine solution injection system.

B. Related sections:
1. Section 01 14 40 – Construction and Schedule Restraints
2. Section 01 91 14 – Equipment Testing and Startup.
3. Section 09 90 00 – Painting and Coating.
4. Section 26 05 10 – Electrical Motors.
5. Section 26 29 23 – Variable Frequency Drive Units.
6. Section 40 90 10 – Control Strategies.

1.2 REFERENCES

A. American Bearing Manufacturers Association (ABMA)
1. 9 - Load Ratings and Fatigue Life for Bail Bearings.
2. 11 – Load Ratings and Fatigue Life for Roller Bearings.

B. American Society of Mechanical Engineers (ASME):
1. B16.1 – Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 300.
2. B16.5 – Pipe Flanges and Flanged Fittings.

C. ASTM International (ASTM):
1. A 48 - Standard Specification for Gray Iron Castings.
2. A 53 – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
3. A 108 - Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality.
4. A 276 - Standard Specification for Stainless and Heat Resisting Steel Bars and Shapes.
5. A 283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
6. A 322 - Standard Specification for Steel Bars, Alloy, Standard Grades.
7. A 494 - Specification for Castings, Nickel, and Nickel Alloy.
8. A 743 - Standard Specification for Casting, Iron-Chromium, Iron-Nickel, Corrosion Resistant, for General Application.
9. A 890 - Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
10. B 367 - Specification for Titanium and Titanium Alloy Castings.
11. E 10 - Test Method for Brinell Hardness of Metallic Materials.

D. American National Standards Institute (ANSI)/Hydraulic Institute (HI):
1. 2.1-2.5 – Vertical Pumps Nomenclature, Definitions, Application, and Operation.
2. 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application, and Sound Measurement and Decontamination.

1.3 DEFINITIONS

A. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in ANSI/HI 2.1 – 2.5, and 9.1-9.5 and as modified in this Section.

B. Flow, head, efficiency, and motor horsepower specified in this Section are minimum values unless stated otherwise.

C. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

D. Tolerances: In accordance with ANSI/HI 2.1 – 2.5 and 9.1-9.5, unless specified more restrictively.

1.4 SYSTEM DESCRIPTION

A. Components: Pump, driver, motors, variable frequency drives, and drive arrangements as specified or as scheduled with shafts, columns, intermediate bearings, seals or packing, couplings, base plates, guards, supports, anchor bolts, necessary valves, gauges, taps, lifting eyes, stands, and other items as required for a complete and operational system.

B. Design requirements:
   1. Pump performance characteristics: As specified in the Pump Schedule of these Specifications.
   2. Pump curve shall be continuously rising throughout the design conditions indicated in the pump schedule.
   3. Motor characteristics: As specified in the Pump Schedule.

1.5 SUBMITTALS

A. Submit in accordance with Section 01 33 20 – Submittal Procedures.

1.6 QUALITY ASSURANCE

A. Provide pumps in this Section from same manufacturer.

B. Require pump manufacturer to furnish and coordinate pump, driver, drive, and pump components as scheduled below and to provide written installation and check out requirements.

C. Manufacturer qualifications:
   1. Experience: Demonstrate minimum 5 years experience in manufacture of vertical, centrifugal booster pumps which have been successfully utilized in municipal water/wastewater applications.
   2. References: Provide a reference list of at least 5 different installations in municipal water/wastewater applications in the continental United States, where the manufacturer has supplied equipment substantially similar in design and characteristics to that proposed here. The installations listed must:

a. Have been designed and fabricated by the manufacturer.
b. Be at least equal to the horsepower to that of the largest unit specified.
c. Have been in continuous operation for last 5 years.
d. Include in the list the name, address, and telephone number of the OWNER, horsepower, and the time in operation.

1.7 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01 33 20 – Submittal Procedures.

1.8 PROJECT CONDITIONS

A. Environmental requirements: As specified in Section 01 11 80 – Environmental Conditions.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate work with restrictions specified in Section 01 14 40 – Construction and Schedule Restraints.

1.10 WARRANTY

A. As specified in Section 01 33 20 – Submittal Procedures.

1.11 MAINTENANCE

A. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

B. Provide the following spare parts:
1. Pump thrust bearing set.
2. Gasket set.
3. Motor bearing set of each type.

PART 2 -- PRODUCTS

2.1 MANUFACTURERS

A. Service: Pump shall be capable of boosting pressure from 80 psi to 150 psi. Service fluid solution consists of chlorine gas injected into utility water solution (1 mg/L).

B. Contractor shall furnish one (1) of the following chlorine solution booster pump models or equal.
1. Wilo Helix EXCEL 50-10
2. Sulzer CPT 12-1
3. Sulzer A22-32-CC LF
4. Grundfos Hydro Multi-E 3 CRE 15-5

2.2 MATERIALS

A. General: Materials in the Pump Schedule shall be the type and grade as specified below.

B. Cast iron: ASTM A 48, Class 30 minimum.

C. Nickel Cast Iron: ASNI/ASTM A 48, minimum Class 30, cast iron with 3 percent nickel.

D. Gray Iron Casting: ASTM A 278, Class 30.

E. Stainless steel: ASTM A 276, type as scheduled.

F. Duplex Steel: ASTM A890 3A

G. Neoprene: Polychloroprene rubber.

H. EPDM: Ethylene Propylene Diene Monomer Rubber

2.3 GENERAL PUMP CONSTRUCTION

A. Type: Industrial, heavy duty, booster pumps meeting the performance requirements and features scheduled and specified herein.

B. Suction and Discharge Flange: ANSI B16.1 rated for 1.10 times the pump shutoff head.

C. Fasteners: Provide Type 316L stainless steel fasteners.

D. Other requirements:
   1. Vibration: As specified in Section 22 05 48 – Vibration & Seismic Controls for Plumbing, Piping, and Equipment.

2.4 PUMP CASINGS

A. Type: 1 piece volute type with integral suction and discharge nozzles.

B. Material: As scheduled.

C. Design Working Pressure: Minimum 1.10 times maximum shutoff total dynamic head with maximum installable impeller diameter at maximum operating speed plus maximum suction static head.

D. Hydrostatic test: 10-minute hydrostatic test at minimum 1.5 times Design Working Pressure.

2.5 IMPELLERS

A. Type: As scheduled.

B. Material: As scheduled.

C. Method of securing to shafts: Impeller is keyed to shaft.

D. Balance: Vibration criteria as specified in Section 22 05 48.

2.6 PUMP SHAFTS

A. Material: As scheduled.

B. Strength: Able to withstand minimum 1.5 times maximum operating torque and other loads.

C. Solid shaft with bronze sleeve.

2.7 BEARINGS AND BEARING FRAME

A. Bearing type: Anti-friction meeting ABMA standards; self-aligning spherical roller type radial bearings; single row ball bearings.

B. Bearing lubrication: Grease lubricated as scheduled.
   1. Provide external grease fittings with grease relief pipe.
   2. Size sufficiently to safely absorb heat energy normally generated in bearing under maximum ambient temperature of 60 degrees Celsius.

C. Bearing life: ABMA L10 life of 20,000 hours at Design Flow and Design Head in accordance with ABMA 9 or ABMA 11 or 100,000 hour medium bearing life.

2.8 COUPLINGS

A. Types: Not required.

2.9 SUPPORTS, PEDESTALS, AND BASEPLATES

A. Type: Provide baseplate and supports in accordance with ASME B73.1.

B. Materials: Same as pump casing.

C. Pump and driver support strength: Able to withstand minimum 1.5 times maximum imposed operating loads or imposed seismic loads, whichever is greater.

2.10 EQUIPMENT GUARDS

A. Type: Not required.

2.11 DRIVERS

A. Horsepower: As scheduled.

B. Motors: As scheduled and as specified in Section 26 05 10.

C. Variable frequency drives: As scheduled and as specified in Section 26 29 23.

D. Other drivers: As scheduled and as specified in sections listed in the Schedule.

2.12 CONTROL SYSTEM

A. Provide control system with equipment protective devices for safe operation in a local control panel and with remote inputs and outputs as indicated on the Drawings to provide the control functions as specified in Sections 40 90 10.

2.13 FINISHES

A. Prepare surfaces and apply protective finishes as specified in Section 09 90 00.

2.14 SOURCE QUALITY CONTROL

A. Witnessing: Source or factory testing shall be witnessed by the ENGINEER or OWNER when scheduled; provide advanced notice of source testing as specified in Section 01 91 14.

B. Equipment performance test: test level as scheduled; test as specified in Section 01 91 14.

C. Vibration test: Test level as scheduled; test as specified in Section 01 91 14.

D. Noise test: Test level as scheduled; test as specified in Section 01 91 14.

E. Variable frequency drive and motor factory tests: Test as specified in scheduled section.

F. Hydrostatic pressure tests: As specified for components in this Section.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

A. Witnessing: All field-testing shall be witnessed by the ENGINEER; provide advanced notice of field-testing as specified in Section 01 91 14.

B. Inspection and checkout: As specified in Section 01 91 14.

C. Equipment performance test: Test level as scheduled; test as specified in Section 01 91 14.

D. Vibration test: Test level as scheduled; test as specified in Section 01 91 14.

E. Noise test: Test level as scheduled; test as specified in Section 01 91 14.

F. Operational testing: As specified in Section 01 91 14.

3.3 MANUFACTURER'S FIELD SERVICES

A. Require manufacturer to inspect system before initial start-up and certify that system has been correctly installed and prepared for start-up as specified in this Section and in Section 01 91 14.

3.4 PUMP SCHEDULE

Contractor is to provide one (1) pump that meets the following criteria and is rated for service per Section 2.01 of these Specifications.

General Characteristics	
Service Fluid	Chlorine gas solution in utility water (1 mg/L)
Quantity	1
Pumped Fluid Temperature, minimum (°F)	33
Pumped Fluid Temperature, normal (°F)	50
Pumped Fluid Temperature, maximum (°F)	68
Initial Pressure (psi)	80
Required Pressure (psi)	150
Pump Characteristics	
Impeller Type	Enclosed
Bearing Lubrication	Grease
Shaft Seal Type	Double Mechanical
Coupling Type	Not Required
Speed Control	Variable Frequency
Suction Flange Size, minimum (in.)	2.5
Discharge Flange Size, minimum (in.)	2.5
Head, maximum (ft)	450
Rated Design Point (at maximum rpm):	
Inlet Flow, (gpm)	50
Differential Head, (ft)	242.3-346.5
Pump Materials:	
Pump Casing	304 SS, 316L SS, Cast Iron, Duplex Steel or equal
Impeller	316L SS or equal
Impeller Wear Ring	None
Casing or Suction Head Wear Ring	316L SS or equal

Shaft	AISI 304L /AISI 318 LN or equal
Shaft Sleeve	AISI 316L or equal
Driver Characteristics:	
Driver Type	Motor with VFD
Variable Frequency Drives Specification Section	Section 26 29 23
Drive Arrangement	Horizontal
Non-reverse Ratchets	None
Driver Horsepower Range	3 – 11
Motor Characteristics (when motor is driver type):	
Motor Specification Section	Section 26 05 10
Service Factor	1.15
Voltage/Phases/Hertz	460/3/60
NEMA Enclosure Type	TEFC
Source Quality Control Testing:	
Test Witnessing	Witnessed
Performance, Vibration, and Noise Test Level	As specified in 01 91 14
Field Quality Control Testing:	
Performance, Vibration, and Noise Test Level	As specified in 01 91 14

END OF SECTION

SECTION 43 24 03.11
VERTICAL DIFFUSER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide vertical diffuser pumps and drives with associated appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 43 20 10 – Pumps, General apply to this Section.

C. The Supplier shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump that will best satisfy the indicated requirements. The supplier of the pump, motor and appurtenances shall have been in business for not less than 10 years. The primary function of the supplier shall be water pumps and motors. Each type of pump listed in this section shall be provided under a single source of responsibility. Different manufacturers and suppliers will be considered under these specifications for each type of pump.

1.2 CONTRACTOR SUBMITTALS

A. Shop Drawings: Submittals shall be made in accordance with Section 01 33 20 – Submittal Procedures and Section 43 20 10 – Pumps, General.

B. Spare Parts List: The Contractor shall obtain from the manufacturer and submit at the same time as Shop Drawings a list of manufacturers suggested spare parts for each piece of equipment specified. The Contractor shall also furnish the name, address and telephone number for the nearest distributor for each piece of equipment.

C. Operation and Maintenance Manual: Provide technical operation and maintenance manuals in accordance with Section 01 33 20 – Submittal Procedures

D. Factory Test Data, Engineered Structural Frequency Analysis, and Certifications in accordance with Section 43 20 10 – Pumps, General.

1.3 QUALITY ASSURANCE

A. All pumps shall be factory tested and an engineered structural frequency analysis in accordance with Section 43 20 10 – Pumps, General.

B. Provide pump manufacturer's standard one-year warranty which starts upon substantial completion of the project.

C. Coordinate with foundation block and support with pump manufacturer for anchorage acceptability.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pumps shall be the product of a manufacturer regularly engaged in manufacturing pumps for the intended application. All equipment shall be of heavy-duty construction and conform to related U. S. manufacturing and performance standards. Each pump shall be provided with a stainless-steel nameplate with pump number, manufacturer name, model number, serial number, horsepower, flowrate, head capacity, speed, etc. All pumps and motors shall be capable of operating within specified parameters without permanent damage or excessive vibration.

B. For the vertical turbine pumps, the complete pumping system consists of the vertical electric motor, vertical turbine pump, drive shaft, and pump bowls and impellers with related items furnished with each of these major elements. The pump manufacturer shall furnish all this equipment and any related and required components and systems under a single source responsibility, and shall coordinate the selection, design, fabrication and assembly of the complete and integrated pumping systems.

C. For the vertical mixed flow pumps, the complete pumping system consists of the vertical electric motor, vertical mixed flow pump, drive shaft, and pump bowls and mixed flow impellers with related items furnished with each of these major elements. The pump manufacturer shall furnish all this equipment and any related and required components and systems under a single source responsibility, and shall coordinate the selection, design, fabrication and assembly of the complete and integrated pumping systems.

D. Pumps will be operated by Variable Frequency Drives. The pump manufacturer is not required to furnish the VFD equipment, but shall ensure that the pumping systems are compatible with the drives and controls and suited for the intended operation, and the pump supplier shall be the single source responsible for the pump and motor. See applicable Sections in Divisions 26 and 40.

E. The secondary reuse pump station will pump treated and filtered water from the wet well to either a secondary reuse system with an open-air storage reservoir (secondary reuse pumps - vertical turbine pumps), or to a nearby manhole to discharge into C-7 ditch (effluent return pumps - vertical mixed flow pumps).

F. Pump Identification:

Pump Name	Secondary Reuse Pumps (Vertical Turbine)	Effluent Return Pumps (Vertical Mixed Flow)
Equipment Numbers	70-P-0031 70-P-0032 70-P-0033 70-P-0034	70-P-0041 70-P-0042 70-P-0043
Location	Secondary Reuse Building	

2.2 OPERATING CONDITIONS

A. The Pumps of this Section shall be suitable for long term operation under the following conditions (see construction drawings, schedules and related technical information):

Parameter	Units	Value
Duty		Continuous
Drive		Vertical electric motor for variable speed operation
Ambient environment		Indoors
Ambient temperature	Deg. F	35 to 110
Ambient relative humidity	%	20 to 95
Fluid service		Treated and filtered WRF effluent
Fluid temperature	Deg. F	40 to 85
Fluid pH range		6.5 to 9.5
Fluid specific gravity		1.0
Maximum Noise	dBA at 3 ft.	85
Pass Minimum Sphere Size	Inches	0.5
Fluid viscosity	absolute centipoises at 60 deg. F	1.14
Project site elevation	ft., msl	4228.40±
Minimum water surface in wet well	ft., msl	4218.00
Max water surface elevation in wet well	ft., msl	4225.60
Centerline Discharge Flange Elevation	ft. msl	4232.50
Operating Floor Elevation	ft. msl	4229.50
Wet Well Floor Elevation	ft. msl	4210.17

2.3 PERFORMANCE REQUIREMENTS

A. Pumps shall meet the following minimum performance requirements:

Parameter	Units	Value		
		70-P-0031 70-P-0032 70-P-0033	**70-P-0034**	**70-P-0041 70-P-0042 70-P-0043**
Design flow capacity	gpm	1,616	550	1,085
Design flow head TDH (see Note 1)	ft	345	298	23
Design flow minimum efficiency	%	84.6	83.5	79.5
Minimum efficiency at reduced flow	%	70	70	70
Shutoff or maximum head	ft	451	447	28
NPSH available	in	33.5	33.5	33.5
Max. NPSH required at design condition (basis of design)	ft	15.0	10.9	29.5
Maximum pump speed	rpm	1800	1800	1800
Maximum motor speed	rpm	1800	1800	1800
Minimum motor size (see Note 2)	HP	200	60	10

1. *Note performance points indicated are for the required flow and head conditions at the centerline of the discharge flange. Supplier to account for head losses within the column and other internal pump components and the water surface and pump system elevations in the design of the pump.
2. Motor size may vary by pump manufacturer performance characteristics and may need to be larger than the minimum motor size indicated to achieve specified pumping system performance points.

B. Pump Dimensions: Each pump shall meet the following dimensional requirements:

Parameter	Units	Value		
		70-P-0031 70-P-0032 70-P-0033	**70-P-0034**	**70-P-0041 70-P-0042 70-P-0043**
Approximate length from Centerline of Discharge to suction bell/impeller, final length determined by manufacturer	ft.	21’-2”	21’-2”	21’-2”
Minimum column diameter	in	10	6	10
Minimum discharge diameter	in	10	6	10
Discharge flange rating	psi	150	150	150
Maximum bowl diameter	in	14	10	14

2.4 MATERIALS OF CONSTRUCTION

A. Each vertical diffuser pump shall conform to the following requirements:

Bowls	Cast-iron or Ductile iron as required for hydraulic criteria, lined with 3 coats of epoxy having a total thickness of 16 mils and the exterior surfaces of the bowl units shall be coated with 12 mils of epoxy. Submerged epoxy (System No. 1) in accordance with Section 09 90 00 –Coatings and Painting
Impeller	Bronze statically and dynamically balanced
Impeller shaft method of connection	Type 316 stainless steel impeller lock collet
Wear rings	Replaceable, Heat Treated 410 stainless steel – Non-galling with impeller wear rings heat treated to a hardness of at least 50 BHN above the bowl wear rings
Bowl shaft	Stainless steel, 416
Suction bell	Cast iron bell, with bottom bearing (high lead tin bronze, ASTM B 584, 93800) and streamlined ribs, Epoxy lining and coating to match bowls. Permanently grease lubricated
Column	Steel pipe, ASTM A53 Grade B not less than Schedule 30, Flanged, epoxy lined and coated 16 MDFT, per section 09 90 00, System No. 1, in maximum 10-ft lengths.
Line shaft and couplings	Stainless steel, Type 17-4 PH or Type 416 in maximum 10-ft lengths, sized for a critical speed of min 20 percent above max operating speed open.
Shaft lubrication	Product Water Lubricated
Shaft seal	Lubricated mechanical seal
Line shaft bearings	Line shaft bearings shall be of the highest quality bearing bronze, self-centering, with turnout lugs or other suitable feature to enable easy removal and installation, and spiral oil grooves. Maximum spacing 10 feet.
Discharge head	Fabricated steel, reinforced and anchored to withstand pipe thrust, pressure, and natural resonance frequencies (torsional, radial or axial), epoxy-lined and coated per 09 90 00, System No 1. 16 MDFT, with flange, base plate, and pressure switch, and drain connections as shown on the Drawings or as otherwise required.
Motor shaft coupling	Shaft coupling shall be Type 410 stainless steel, threaded or keyed to the shaft, adjustable spacer type.
Bowl and suction case bearings	Product water lubricated, High Lead Tin bronze sleeves case bearings above and below each impeller
Suction Strainer	316 Stainless steel

2.5 SEAL AND FLUSHING WATER FOR PUMPS

A. All pumps shall be equipped with product water flushing, lubrication and seals line. For clarity seal waterlines are not shown on the drawings plan view, but detailed below to be coordinated by the pump manufacturer.

B. The required piping and control valves of product water flushing and seal water system for each pump shall be as indicated in the Figure 1 below and shall be coordianted and sized with the pump manufacurer.

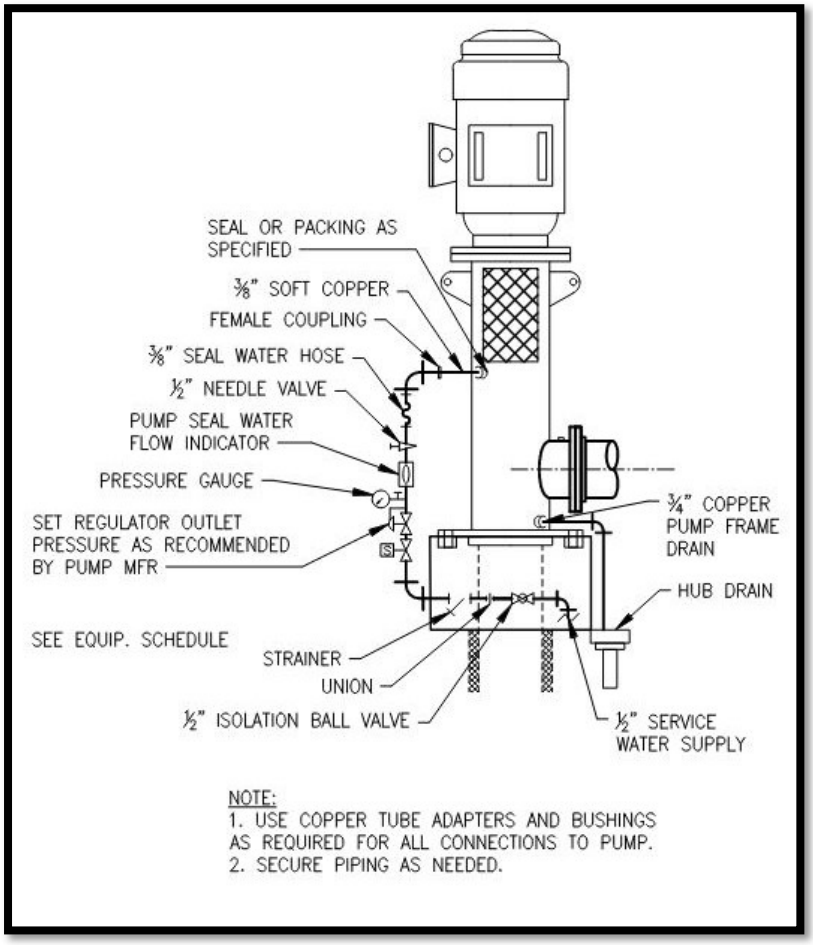


Figure 1 - Pump Product Water Flushing and Seal Piping.

2.6 ELECTRICAL REQUIREMENTS

A. Drive: Each pump shall be provided with a vertical, solid shaft, premium efficiency, high thrust, inverter duty, WP1, 480 volt, 3-phase, 60-Hertz heavy duty, electric motor in accordance with Section 26 20 00 – Low-Voltage AC Induction Motors. Each electric motor shall be designed to accept the total, unbalanced thrust imposed by the pump. Thrust bearings shall be insulated and shall be rated for a minimum L-10 life of 100,000 hours.
1. Motor to include a non-reversable ratchet.

B. Motors larger than 50 HP or where indicated shall be provided with 120 volt AC space heaters, wired to a terminal strip in a low voltage motor junction box. If provided by the manufacturer when not specified, the manufacturer shall not require that they be connected or the CONTRACTOR shall connect them at no extra cost to the OWNER, in order to keep the warranty in force.

C. Pumps shall be adjustable speed and Contractor shall coordinate supply of variable speed drives in accordance with Section 26 29 23 – Variable Frequency Drives.

2.7 CONTROLS & INSTRUMENTATION

A. Pumps shall be controlled in accordance with Divisions 40 and 26.

2.8 SPARE PARTS

A. Furnish the following spare parts for a single pump unit of each type specified:

Item	Number
Items Recommended in 1.2.B above	As recommended
Mechanical Seal Rebuild Kit	1
Sets of Gaskets and O-rings	2

2.9 MANUFACTURER'S, OR ENGINEER APPROVED EQUAL:

A. Listing of a manufacturer does not warrant that their equipment or commercial conditions will conform to the technical or bidding requirements given herein, or that their proposed standard or alternative offerings will be suited for the service, or that the equipment will be accepted by the Engineer, or that pricing, delivery or other terms will be competitive. The CONTRACTOR shall review information provided by prospective suppliers to assure compliance with the requirements of the Contract Documents and shall be fully responsible for the manufacturer's conformance thereto.

1. Vertical Turbine Pumps - Secondary Reuse
    a. American Marsh
    b. Floway
    c. FlowServe
    d. Goulds Pumps, Inc.
    e. National Pump Company (Basis of Design)
    f. Sulzer Johnston

2. Vertical Mixed Flow Pumps - Effluent Return
    a. American Marsh (Basis of Design)
    b. Floway
    c. FlowServe
    d. Goulds Pumps, Inc.
    e. National Pump Company
    f. Sulzer Johnston

PART 3 - EXECUTION

3.1 SERVICES OF MANUFACTURER

A. Factory Testing: Factory tests shall be performed on all full-size pumping equipment as specified in Section 43 20 10 –Pumps General

B. The installation shall be in accordance with the manufacturer's written recommendations and as shown in the drawings.

C. Anchor Design: The pump manufacturer shall provide analyses to determine the anchorage and other requirements necessary to ensure that the pumping equipment is adequately designed, fabricated, installed, and anchored to resist operating forces and meet associated performance standards. Equipment design and anchorage shall be sufficient to resist pump dynamic forces without damage or vibration to the equipment (pump, pump can drive shaft and motor) and the supporting structure. Manufacturer shall determine the location, number, diameter, anchor embedment, and related requirements for anchor bolts and other associated elements of the installation.

D. Inspection, Startup, and Field Adjustment: The service representative of the manufacturer shall be present at the Site for 3 8-hour workdays, to furnish the services required by Section 43 20 10 – Pumps, General.

E. Instruction of Owner's Personnel: The training representative of the manufacturer shall be present at the Site for 1 8-hour workday to furnish the services required by Section 43 20 10 – Pumps, General.

F. For the purposes of this paragraph, a workday is defined as an 8-hour period at the Site, excluding travel time. All on-site work hours shall be coordinated with the Owner and/or General Contractor.

G. The Engineer may require that the inspection, startup, and field adjustment services above be furnished in 3 separate trips.

3.2 FIELD TESTS

A. Field tests shall be performed and documented test reports provided according to Section 43 20 10, as suited to the pumps provided under this section. Some of the listed requirements may not be applicable to the particular equipment installed. Provide a written plan identifying the field tests that will be performed, sequencing, etc.

B. Prior to Owner acceptance and formal pump station start-up, all equipment shall be inspected for proper alignment, quiet operation, proper connection, and satisfactory performance by means of a function test in the presence of the Owner and the Engineer. A start up report showing function testing, motor voltages, and running amperages shall be provided to the engineer after pump station start-up. The Contractor and manufacturer shall also sign the certification of proper pump installation attached to this specification.

END OF SECTION

Certificate of Proper Installation

Project: Magna WRF Reuse Project

Contractor: _____

Pump Manufacturer: _____

I hereby certify that:

1. I am an authorized representative of the contractor/manufacturer
2. The pump installation has been made properly in accordance with the manufacturer's recommendations.
3. Field testing as specified in Sections 43 20 10 and 43 24 03 has been completed and the pump has satisfactorily met all performance requirements.

Signatures

Contractor: _____
Date: _____

Manufacturer: _____
Date: _____

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SECTION 43 25 11
SUBMERSIBLE SUMP PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide submersible sump pumps, related controls and appurtenant work, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 11 00 00 - Equipment General Provisions, Section 43 20 10 – Pumps, General apply to the Work of this Section.

C. The Supplier shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump, which will satisfy the indicated requirements.

1.2 REFERENCE STANDARDS

A. Refer to Section 43 20 10 – Pumps, General for applicable standards.

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings: Submittals shall be made in accordance with Section 01 33 20 – Contractor Submittals and Section 43 20 10 – Pumps, General.

B. Spare Parts List: The Contractor shall obtain from the manufacturer and submit at the same time as Shop Drawings a list of manufacturer suggested spare parts for each piece of equipment specified. The Contractor shall also furnish the name, address and telephone number for the nearest distributor for each piece of equipment.

C. Operation and Maintenance Manual: Provide technical operation and maintenance manuals in accordance with Section 01 33 20 – Contractor Submittals.

1.4 QUALITY ASSURANCE

A. Provide pump manufacturer's standard one-year warranty which starts upon substantial completion of the project.

PART 2 - PRODUCTS

2.1 SUMP PUMPS

Equipment Number	70-P-0051 70-P-0052
Location	Secondary Reuse Building – Dry Well
Maximum shutoff head, ft.	50

Design flow capacity, gpm	110
Design flow pump head, TDH ft	25
Design flow minimum pump efficiency, percent	36
Maximum pump speed, rpm	3600
Minimum motor size, hp	2
Maximum pump discharge size, inches	3
Discharge rating, psi	100

A. Identification

B. Operating Conditions: The Work of this Section shall be suitable for long term operation under the following conditions:

Duty	Intermittent
Drive	Constant speed
Ambient environment	Submerged
Ambient temperature, degrees F	30 to 110
Ambient relative humidity, percent	40 to 100
Fluid service	Floor drains and wash down/storm water
Fluid temperature, degrees F	40 to 85
Fluid pH range	6.5 to 8.5
Fluid specific gravity	1.01
Fluid viscosity (absolute), centipoises at 60 deg. F	1.0
Project site elevation, ft. a.s.l	4229.50
Minimum available NPSH, ft	27
Maximum size of spheres to pass, in. dia.	1-1/2

2.2 PUMP REQUIREMENTS

A. Construction: Construction of submersible sump pumps shall conform to the following requirements:

Pump casing	Cast iron
Impeller	Semi-open, non-clog cast iron
Bearings	Permanently lubricated ball and sleeve type or vortex
Shaft	Stainless steel, series 400
Seal	Mechanical seal
Pump Connection	Flange
Mounting Method	Material: Type 316 stainless steel, with the following features: 1. Free standing pedestal style. 2. Lifting chain of sufficient strength and length to permit safe removal of pump unit from sump.

B. Drive: Enclosed, submerged, electric motor, suitable for 480-volt 3-phase, 60 Hz ac power supply, with armored cable, in accordance with Section 26 24 19 – Low-Voltage AC Induction Motors and as specified in this Section.

1. Motor Characteristics:
    a. Type: Squirrel cage induction motor, shell type design.
    b. All electrical parts in air filled water tight housing.
    c. Horsepower: As scheduled. Listed motor horsepower is the minimum to be supplied. Increase motor horsepower if required to prevent motor overload while operating at any point on the supplied pump operating head-flow curve, including runout. However, motor control center (MCC) and other electrical equipment are sized as specified.
    d. Motor Efficiency: As scheduled.
    e. Service Factor: 1.15.
    f. NEMA Design Type: B.
    g. Motor Insulation: Class F, moisture resistant, able to withstand 40 degrees Celsius ambient temperature plus 105 degrees Celsius temperature rise.
2. Provide motors that are rated suitable for continuous operation in 40 degrees Celsius ambient temperature at project site altitude.
3. The motor shall be designed for continuous duty handling pumped media of 40 degrees Celsius and capable of a minimum of fifteen (15) evenly spaced starts per hour.
4. The motor shall be capable of continuous operation under load with the motor submerged, partially submerged or exposed, without derating the motor.
5. If cooling jacket required, provide with the following:
    a. Non-clogging ports and channels that use pumped fluid as the cooling media.
    b. Functional with motor submerged, partially submerged, or exposed.
    c. Spray systems, air moving equipment or other secondary cooling systems are not acceptable.
6. Motor Sealing: Design motor case and seals to withstand 65 feet of submergence.
7. Thermal Protection: Provide automatic reset motor stator temperature detectors, 1 switch in each phase winding. If any detector is activated, the sensor shall activate an alarm and shut down the motor. The thermal detectors shall activate when the stator temperature exceeds 125 degrees Celsius.
8. Moisture Detection: Provide a moisture detection sensor in the seal chamber or motor housing. If leakage is detected in the stator chamber, the sensor shall activate an alarm and shut down the pump/motor.
9. The thermal protection switch and moisture detection device shall be monitored by a monitoring relay supplied with the pump and installed in the local control panel.

C. Control: Sump pump controls shall be housed in NEMA rated cabinets as required in Section 26 00 00 – General Requirements for Electrical Work. All control cabinets shall be equipped with a hinged, gasketed door with mounting brackets or pedestal with all necessary components to provide the following functions for each pump:
    1. Magnetic starter
    2. Circuit breakers
    3. Hand-Off-Auto selector switch
    4. Pilot lights
    5. Alarm reset switch, one only
    6. Integral float switch control

2.3 PROTECTIVE COATING

A. Pumps shall be coated in accordance with Section 09 00 00 – Painting and Coating.

2.4 MANUFACTURERS, OR ENGINEER APPROVED EQUAL

A. ABS Pumps, Inc.

B. Flygt Corporation

C. Grundfos

D. Hydromatic

E. Tsurumi (Basis of Design)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pumping equipment shall be installed in accordance with the Shop Drawings and as indicated.

B. General installation requirements shall be in accordance with Section 43 20 10 – Pumps, General.

END OF SECTION

SECTION 43 42 02
BLADDER SURGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Surge tanks.

B. Related Sections:
1. Section 01 33 20 – Contractor Submittals
2. Section 09 90 00 – Painting and Coating
3. Section 40 05 10 – Mill Piping, Exposed and Buried

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM):
1. A 36 - Specification for Structural Steel.

B. American Society of Mechanical Engineers (ASME):
1. ASME Code - Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels, Division 1.

C. Code of Federal Regulations (CFR):
1. 49 CFR 173.315 - Code of Federal Regulations, Part 173, Section 315 - Compressed Gases in Cargo Tanks and Portable Tanks.
2. 49 CFR 178 - Code of Federal Regulations, Part 178, Subpart J - Specifications for Containers for Motor Vehicle Transportation.

1.3 SYSTEM DESCRIPTION

A. The surge control system shall be designed, fabricated, installed and warranted by a single supplier to meet the functional and performance requirements specified herein.

B. The work included in this section consists of the furnishing of all labor, materials, equipment, testing and appurtenances for surge protection at each location specified to prevent column separation and/or to limit surge under the conditions specified.

C. The bladder type surge tank shall consist of a cylindrical pressure tank for surge control, including: bladder, shell assembly, gas plate assembly, rupture disc, pressure gauges, accessories, valves, connection piping, and other miscellaneous appurtenances

1.4 SUBMITTALS

A. General: Supply the information required below in accordance with Section 01 33 20 – Contractor Submittals.

B. Product Data: List of materials and coatings used. All materials in contact with water shall be NSF certified (exempting Type 304 or 316 stainless steel).

C. Shop Drawings and Calculations:
1. Detail drawings or manufacturer's literature to indicate compliance with the specified requirements.
2. Dimensional drawings indicating vessel dimensions, wall thickness, mounting, and anchorage requirements.
3. Hydraulic calculations as required herein.
4. Copy of structural, seismic, and wind loading calculations for the support system signed by a Structural Engineer registered in the state where the Project is located.
5. Layout drawings showing dimensions of equipment and accessories.
6. Manufacturer's catalog data on all appurtenances.
7. Submit electrical schematic and wiring diagrams showing wiring, monitoring, and terminals. Label each terminal, showing which control or electrical power wire connects to which terminal.

D. Owner's Manual:
1. Certification and ASME Code data reports in accordance with the ASME Code and as applicable 49 CFR 178.337 or other similar codes. The certification shall include certification of post weld heat treatment (as required by ASME codes), joint radiography, and hydrostatic testing.
2. Fabrication drawings.
3. Operation and maintenance data and instructions.
4. Certificate of installation, signed by authorized supplier/manufacturer representative following field inspection, functional testing and performance testing of systems.

E. Manufacturer's Warranty
1. Manufacturer warranty or warranties for the surge tank and all appurtenances. Said warranties shall be issued to Owner and shall be valid for a period of 2 years following installation.

PART 2 - PRODUCTS

2.1 GENERAL

A. Hydraulic Design
1. The tank supplier shall conduct a pressure surge analysis of the pumping system to verify the tank and appurtenances supplied will perform as intended. Initial surge tank design as shown in the contract documents is as follows:

a.	Volume	2,000 gallons
b.	Dimensions	As shown in drawings
c.	Initial Pre-charge Pressure	37 psi
d.	Hydraulic Resistance Out of Tank (Including connection piping)	0.12 ft/cfs^2
e.	Hydraulic Resistance Into Tank (Including connection piping)	12 ft/cfs^2

f. This design shall be the basis of bid. Any proposed changes identified during the supplier's analysis shall be addressed during the submittal process with

additional time or cost assessed in accordance with the provisions of the Contract Documents.

2. System Parameters: The system for which the surge control is to be provided consists of a secondary water pump station rated at 150 psi. Assume the following values or factors in evaluating the tank:

a.	Friction factor	Hazen-Williams C=120
b.	Maximum Flow rate through pump station	3,230 gpm
c.	System static pressure	105 psig
d.	Maximum steady operating pressure	140 psig
e.	Maximum allowable pressure due to surge	150 psig
f.	Minimum allowable pressure due to surge, point in pipeline	No Column separation at any
g.	Water temperature range	[0-30°C]

   h. The pressure vessel is to be connected to the pipeline as shown on the plans.
   i. The hydraulic and pressure surge analysis is available on request from the Engineer.

3. Evaluation Criteria: Evaluate the surge tank during a power failure to the pump station at the maximum flow rate indicated above. Size tank with allowances for a 10% volume seal at lowest surge pressure anticipated at tank after power failure at the maximum flow rate. In no case shall the tank volume be less than the design value identified above. The surge analysis submitted by the supplier shall include input data for the piping system, initial flow rate, initial and maximum expanded air volume and envelope of maximum and minimum line pressure throughout the pipe system. In addition, a predicted pressure-time history at the surge tank and at other critical points in the pipe system will also be required.

B. Pressure Vessel:

1. Materials for the tank, design, and shop fabrication and inspection shall comply with Section VIII of the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels, with only the plate steels in Table UCS-23 of said code being used. The design pressure rating of the vessel shall be at least the lesser of 50 percent or 50 pounds per square inch gauge above the maximum allowable pressure due to surge. A 1/16 inch corrosion allowance shall be included in all shell, heads, and attachment thicknesses.
2. Provide ASME Code stamp and pressure rating on pressure vessel.
3. Welding: Weld reinforcement shall be in accordance with ASME Code. Excessive reinforcement shall be ground down to within the ASME Code requirements, and as required to install the lining systems. All internal corners and edges shall be ground to a 1/8 inch radius, or a greater radius if required by the lining system.
4. Protective Lining: Interior surfaces of the tank shall be factory-coated with a polyamide epoxy coating, percent of volume solids 75% minimum, (Devoe Bar-Rust 233H or Equal). Apply minimum of 3 coats, with a minimum dry film thickness of 18 mils (total thickness all coats).
5. External Coating: Finished coating to be as specified in Section 09 90 00. At Contractor's option, the exterior portion of the pressure vessel may be shop coated with red primer and finish coats applied in the field, or the finish coat may be shop applied with touch up painting as necessary in the field.
6. Tank shall be equipped with an anti-extrusion grid which prevents the bladder from being sucked out of the tank in case of loss of line pressure. Head loss associated with

the anti-extrusion grid shall be included in the calculation of total connection resistance.

7. All submerged, wetted, or internal items shall be Type 304 or 316 stainless steel. The vessel shall be lined and coated per Section 09 90 00.
8. Provide minimum 12" x 16" elliptical opening or minimum 18" round opening for access manhole, flanged outlet for pipe connection to manifold header, threaded couplings for connecting gages, valves, air piping and drain. Couplings shall be 3,000-pound, WOG forged stainless steel, per ASTM A 182 F 304. Threads shall comply with ANSI B2.1. Joint lubricant shall be Teflon joint compound or Teflon tape.
9. Structural Design: Design tank for seismic, wind load, and other design criteria consistent with other component of the project and as required by local regulations.
10. Vertical tanks shall be supported laterally for seismic restraint, which may include separate structural supports. These supports along with the tank legs, saddle supports, and anchor nuts/bolts shall be sized appropriately to resist movement in a seismic event per the current codes. Seismic design calculations shall be stamped by a licensed structural engineer in the state of Utah and submitted for review.
11. Environmental Service Conditions: As shown on the Drawings, General and/or Structural Notes.
12. Install air lines to drain condensate traps/drains as required and/or shown on the Drawings.
13. Tank to be equipped with a Parker B17 Quick Disconnect (or equal) air valve fitting with a ½" ball valve charging connection to facilitate on-site charging of the tank. Tank to be precharged with nitrogen gas per the precharge pressure specified.
14. Tank to include a replaceable bladder designed for both the precharge and system pressures specified. In no case shall the bladder have a thickness less than 0.100".
15. The tank shall be fitted with a 304 or 316 stainless steel perforated or slotted plate to prevent the bladder from escaping through the fluid port. The presence of this plate shall be included in the resistance calculations for surge tank system.
16. The bladder surge tank shall be equipped with a non-intrusive volume indicator device to monitor gas volume levels without disrupting tank operations.

C. Connection piping:

1. All piping, fittings, flanges, valves, and other connection piping appurtenances shall be rated for a pressure of no less than the design pressure for the tank.
2. All connection piping to the tank shall be designed such that total hydraulic resistance into and out of the tank is within the range specified. Supplier shall provide resistance calculations for the piping and tank system. Any orifice plate or other head loss device required to meet resistance specifications shall be designed and furnished as part of the overall connection piping and tank system. Where resistance requirements cannot be obtained using a single connection pipe, tank supplier shall design and furnish a manifold system (including check valve, bypass piping, etc.) to obtain the required resistance.
    a. Manifold System. Contract drawings assume a bypass piping system integral to the check valve. Manufacturer shall verify that the bypass piping system is adequate and can meet specified resistance requirements.
3. Coating: Coat all connection piping and appurtenances as specified in Section 09 90 00.

D. Safety-Relief Valve: Safety-relief valve shall comply with the ASME Boiler and Pressure Vessel Code. Valve shall be bronze, and shall have a pressure rating of appropriate for the pressure rating of the tank. Valve shall have a bottom NPT inlet, and shall have incorporated a calibrated spring set to allow the valve to open at the tank design pressure. Valve shall be a Kunkle Model 919 or approved equal.

2.2 COMPONENTS

A. Lifting Lugs: Provide lifting lugs.

B. Anchor Bolts: Anchor bolts shall have a nominal diameter of at least 3/4 inch, unless otherwise indicated on the Drawings, and shall be anchored to concrete foundations using methods designed to transfer the full ultimate strength of the anchor bolt to the concrete foundation. Attach anchor bolts to the tank by use of anchor bolt chairs or rings, as required. Chairs or rings shall be designed to transfer 125 percent of the ultimate strength of the bolt, or 150 percent of the calculated load, whichever is less, to the tank shell.

C. Nameplates and Code Stamps: Design, fabricate, and test tanks in accordance with the ASME Code. Each tank shall bear a stainless steel ASME nameplate. Each nameplate shall bear the applicable code symbol. Manufacturer shall be authorized by ASME to apply the applicable code symbols.

D. Fittings and Attachments: Fittings larger than 1 inch shall be flanged. Fittings 1 inch and smaller shall be National Pipe Thread. Reinforce openings in accordance with the ASME Code. Access openings shall be flanged, and, unless otherwise indicated on the Drawings, have a nominal diameter as described in paragraph 2.1.B.8 above. The cover plate and flange of access openings shall each have a net thickness, after machining, of at least 1/2 inch or as required to meet the vessel design pressure.

E. Attachments: Weld shell attachments for pipe supports, tank gages, instruments, and other items as indicated on the Drawings before application of the tank lining.

2.3 SOURCE QUALITY CONTROL

A. Tests: After fabrication, but prior to application of linings each tank shall be tested in accordance with the ASME Code.

2.4 MANUFACTURERS

A. Experience: The manufacturer shall be experienced for at least 5 years in the design and operation of surge control systems and shall provide a list of similar installations for review by the Engineer.

B. Surge Tanks: One of the following or engineer approved equal:
   1. Pulsco (Basis of Design)
   2. Young Engineering
   3. Charlatte Tanks

PART 3 - EXECUTION

3.1 INSTALLATION

A. Special Techniques: Install in accordance with the recommendations of the manufacturer, shop drawings, applicable codes and Contract Documents. Tanks shall be installed level and plumb and shall be secured via their anchor bolt system to transfer all vertical and horizontal loads to their concrete foundations. All appurtenances shall be configured and oriented for easy access as required for tank operation and maintenance.

B. Air Charging: Fully charge with air in accordance with the manufacturer's instructions prior to field testing the system. Final adjustments in pressure shall be made after installation.

C. Contractor is to obtain the required OSHA Pressure Vessel operating permit.

D. Manufacturer's Services: Trained personnel representing the surge tank manufacturer shall check the installation and instruct the Owner's personnel in the operation of the surge control system. A field test of the equipment by the manufacturer's representative shall also be performed in conjunction with this site visit.

END OF SECTION

SECTION 43 70 00
AUTOMATIC, REFRIGERATED SAMPLERS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall furnish and install automatic sampling units and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 91 00 – Process Control and Instrumentation Systems apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1.3 QUALITY ASSURANCE

A. The accuracy of each instrumentation system or loop shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

1.4 MANUFACTURER'S REPRESENTATIVE

A. Manufacturer’s representative services shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

1.5 PRODUCT HANDLING

A. Product handling shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

1.6 GUARANTEE

A. Guarantees shall conform to the requirements of Section 40 91 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 SAMPLERS

A. Indoor refrigerated sampler for the representative collection of liquid water samples to monitor influent and effluent waters from municipal and industrial NPDES facilities, monitor effluent waters from indirect industrial dischargers for compliance with pre-treatment regulations, and environmental monitoring including CSO and SSO studies and storm water run-off.

B. The sampler shall be an Indoor Refrigerated sampler with options outlined below.

C. The naming of a manufacturer is to define minimum acceptable performance and functionality. Other manufacturers may be approved as an equal if they meet the

specifications. CONTRACTOR shall submit alternate equipment specifications as outlined in Section 01 33 00 Submittal Procedures.

D. The method of sample collection shall be via high-speed peristaltic pump for collection of the sample liquid. The method of sample detection shall be ultrasonic

E. SYSTEM DESCRIPTION

1. Performance Requirements

a. Sample cooling: maintain sample liquid at 4°C (39°F) in ambient temperature to 50°C (122°F) maximum; accurate to ±0.8°C (±1.5°F).

b. Sample volume: programmable in 10 mL increments from 10 to 10,000 mL.

c. Sample volume repeatability: ± 5% of 200 mL sample volume with: 4.6 m (15 ft.) vertical lift, 4.9 m (16 ft.) of 3/8-in vinyl intake tube, single bottle, full bottle shut off at room temperature and 1524 m (5000 ft.) elevation.

d. Pacing intervals: selectable in single increments from 1 to 9,999 flow pulses or 1 to 999 hours in 1-minute increments. Accepts 4-20mA input from an external device to pace the sampler.

e. Vertical lift: minimum 8.5 m (28 ft.) using 8.8 m (29 ft.) of 3/8-in. vinyl intake tube at sea level at 20 to 25°C (68 to 77°F).

f. Sample transport velocity: 0.9 m/s (2.9 ft./s) with: 4.6 m (15 ft.) vertical lift (16 ft.) of 3/8-in. vinyl intake tubing, 21°C (70°F) and 1524 m (5000 ft.) elevation.

g. Pump flow rate: 4.8 L/min (1.25 gpm) at 1 m (3 ft.) vertical lift with 3/8-in. intake tube typical.

F. Certifications

1. Controller: CE

2. AC power supply: UL/CSA/CE

3. Cabinet: UL/CSA/CE

G. Environmental Requirements

1. Operational Criteria

a. Operating temperature: 0 to 50°C (32 to 122°F)

b. Storage temperature: -40 to 60°C (-14 to 140°F)

H. Warranty

1. The product shall include a one-year manufacturer's warranty from the date of shipment

I. Maintenance Service

1. Per manufacturer's operation and maintenance manual

J. Equipment

1. The controller housing of the sampler shall be submersible, watertight, dust-tight, corrosion and ice-resistant to NEMA 4X, 6, IP68 standards.

2. The desiccant cartridge, which prevents moisture from accumulating inside the controller electronics area, shall be visual and accessible externally from the side of the controller; the replacement of the desiccant shall not require tools or disassembly of controller from base.

3. The pump shall use spring loaded rollers and be accessible by a clear hinged cover with single thumbscrew.

4. The refrigeration components and copper plumbing shall be corrosion protected with conformal coating.

5. Sample cooling is made with a 1/10 HP, 75-Watt, 400 BTU/hr compressor, 120 CFM condenser fan, and three-sided wrap-around plate type evaporator. Rigid foam insulation is used throughout.

6. An air sensing thermostat shall be capable of maintaining sample liquid within specified limits.

7. The power requirement shall be 115 Vac, 60 Hz (230 Vac optional). The compressor current is 1.5 to 2.0 A, running. The locked rotor current is 12 A. Overload protection is made by a 5 A dc line fuse to the pump and a 1 A dc line fuse (ac power converter). The compressor: thermal overload relay opens at 110°C (230°F).

8. The internal battery shall be a lithium-ion battery (maintains real time clock for five years minimum).

9. The Graphics Display shall be a color, self-prompting, menu-driven program.

10. Communication choices include:

    a. USB and optional RS485 (Modbus)

    b. Permits embedded software upgrades in the field

    c. Data management software used to download, analyze, and report data, save templates, download sample history and event logs, create graphs for reports and presentations. Link directly to PC A to A USB cable.

11. The membrane switch keypad user interface is self-prompting/menu driven program with 2 multiple function soft keys.

12. Sampling pacing modes shall include Time Weighted, Flow Weighted, Time Table, Flow Table, and Event.

13. Datalogging

a. Sample History: Stores up to 4000 entries for sample time stamp, bottle number and sample status (success, bottle full, rinse error, user abort, distributor error, pump fault, purge fail, sample timeout, power fail and low main battery).

b. Measurements: Stores up to 325,000 entries for selected measurement channels in accordance with the selected logging interval.

c. Event Log: Stores up to 2000 entries. Records Power On, Power Fail, Firmware Updated, Pump Fault, Distributor Arm Error, Low Memory Battery, Low Main Battery, User On, User Off, Program Started, Program Resumed, Program Halted, Program Completed, Grab Sample, Tube Change Required, sensor communication errors, cooling failed, heating failed, thermal error corrected.

14. Internal software is protected by a 7-amp fuse.

15. Diagnostics: View event and alarm logs as well as maintenance diagnostics A program lock is provided for access code protection to prevent tampering of program and system settings.

16. The sampler is convertible to composite operation by installing a composite container and full bottle shut off.

17. Sample containers include choice of:

    a. Glass: (1) 2-1/2 gal., (2) 2-1/2 gal., (4) 2-1/2 gal., (8) 0.5 gal., (24) 350 mL

    b. Polyethylene: (1) 5-1/2 gal., (2) 2-1/2 gal., (4) 2-1/2 gal., (8) 0.6 gal., (12) 0.5 gal., (24) 1 L

18. Sampling features include:

    a. Dual programming: Up to 2 sample programs can be run sequentially, in parallel, or according to day-of-week scheduling; enabling a single sampler to function like multiple samplers.

    b. Cascade sampling: for two samplers in combination—the first sampler, at the completion of the program, initiates the second.

    c. Status Screen: Communicates what program is running, if there are any missed samples, when the next sample will be taken, how many samples remain, number of logged channels, time of last measurement, memory available, number of active channels, if alarms were triggered, when alarms were triggered, active sensors and cabinet temperature.

19. Automatic shutdown modes:

    a. Multiple bottle mode: after complete revolution of distributor arm (unless continuous mode is selected).

    b. Composite mode: after preset number of samples have been delivered to composite container, from one to 999 samples, or upon full container.

20. Sample distribution modes include continuous/non-continuous, bottles per sample, or samples per bottle.

21. Manual grab sample can be made with the AS950 sampler to deliver a grab sample to a specific bottle location.

22. The high-speed peristaltic sample pump uses four rollers with spring tension to accommodate larger particles.

23. The intake air purge is made automatically before and after each sample. The duration automatically compensates for varying intake line lengths.

24. The intake line is optionally rinsed with source liquid prior to each sample from one to three times.

25. The sample collection cycle is optionally repeated from one to three times if a sample is not obtained on the initial attempt.

K. Components

1. Standard equipment:

   a. Controller: high impact injection-molded ABS/PC plastic

   b. Base: 22-gauge steel with vinyl laminate overcoat; 201 stainless steel finish optional. Hinged, lockable lid is available as an option.

   c. Pump enclosure: corrosion-resistant polycarbonate door, high impact-resistant plastic, polyphenylene sulfide track

   d. Intake strainers in standard size, high velocity, or low profile for shallow depth applications. Choice of:

      1) Teflon and 316 stainless steel construction

      2) All 316 stainless steel

2. Max Dimensions: 61 x 61 x 112 cm (24 x 24 x 44 in.)

L. ACCESSORIES

1. Bottle kits

2. Tubing and strainers

3. Cables and interfaces

4. Configuration and maintenance software

5. AC battery back up

6. Controller cover

7. IO9000 Input/Output Module

M. Spare Parts: Each sampler shall be furnished with a one-year supply of the manufacturer's suggested spare parts and any other elements subject to wear or frequent replacement. All parts shall be properly labeled and identified with the name and number of the equipment to which they belong.

N. Tools: The CONTRACTOR shall furnish one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment. Tools shall be of best quality and be furnished in labeled toolboxes of suitable design.

O. MANUFACTURERS, OR EQUAL

1. Sigma Model AS950 by Hach

2. Isco, Inc.

3. Or Equal

PART 3 -- EXECUTION

3.1 SAMPLER INSTALLATION SCHEDULE

A. Samplers shall be installed in locations identified as follows:

Identification Number	Location	Sample
70-AE-0033	Reuse Building	Effluent

3.2 Manufacturer's Service and Start-Up

1. Contractor will include the manufacturer's services to perform start-up on sampler to include basic operational training and certification of performance of the sampler.

2. Contractor will include a manufacturer's Service Agreement that covers all the manufacturer's recommended preventative maintenance, regularly scheduled calibration and any necessary repairs beginning from the time of equipment startup through to end user acceptance / plant turnover and the first 12 months of end-user operation post turnover.

3. Items A and B are to be performed by manufacturer's factory-trained service personnel. Field service and factory repair by personnel not employed by the manufacturer is not allowed.

4. Use of manufacturer's service parts is required. Third-party parts are not approved for use.

5. Upon completion of the installation, each piece of equipment and each system shall be field-tested for satisfactory operation without excessive noise, vibration, overheating,

etc. Equipment must be adjusted and checked for misalignment, clearances, supports, and adherence to safety standards.

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DIVISION 46
WATER AND WASTEWATER EQUIPMENT

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SECTION 46 61 25
CLOTH MEDIA FILTERS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. This specification details the performance and design requirements for the Cloth Media Filtration System at the Magna Water District (OWNER) to provide reuse water in accordance with State of Utah requirements. The Filtration System Supplier (FSS) shall provide cloth media filters, complete and operable, in accordance with the Contract Documents

1.2 MANUFACTURER SUBMITTALS

A. Furnish submittals in compliance with Section 01 33 20 – Submittal Procedures.

B. Shop Drawings
   1. Drawings and technical information for equipment, piping, valves, and controls.
   2. Electrical single line diagrams, schematic diagrams, interconnection diagrams, internal wiring diagrams of the filter system including control panel and any auxiliary control or termination panels. Component ratings such as main circuit breaker, branch circuit breakers, and feeder sizes shall be included. Operating characteristics of electrical and control equipment including power consumption, operating voltage, and amperage tolerances, and ancillary electrical services shall be shown.
   3. A complete listing of the PLC control logic with cross-reference listings, data table listings, including symbolic and descriptive names, labels, and comments.
   4. Operator interface screen layouts, with identification of data to be displayed.

C. Technical Manual: The Technical Manual shall contain the required information per Section 01 33 20 – Submittal Procedures.

1.3 SPECIAL CORRECTION OF DEFECTS REQUIREMENT

A. The CONTRACTOR shall furnish a written warranty that the filter will meet the performance and capacity requirements. The warranty shall state that in the event of defects, the CONTRACTOR will make necessary adjustments and repairs to meet the requirements at no cost to OWNER.

B. If it is determined that the filter is unable to meet the performance and capacity requirements or if the filter controls are unsuitable for the ambient environment, the CONTRACTOR shall be responsible to provide a filter system that will comply.

C. It is expected that additional project requirements, including some changes, will be required as the design progresses. The DESIGN-BUILDER (DB) will make every effort to coordinate changes that will affect the Filtration System, but ultimately the FSS is required to comply with these design progression updates.

D. The FSS must provide a complete and functional system that fully complies with the requirements defined in the RFP. The FSS is also responsible for ensuring that their package does not compromise or interfere with the performance of the Magna Reuse Facility.

E. The CONTRACTOR shall correct defective WORK for 12 months from the date of Substantial Completion.

1.4 EXPERIENCE

A. The filter supplier shall furnish documentation of a comprehensive test performed on the filter system by an independent third party in the State of California to show capabilities with the Title 22 requirements.

B. Refer to Section 00 31 00 – Experience for relevant FSS experience requirements.

PART 2 -- PRODUCTS

2.1 GENERAL SYSTEM DESCRIPTION

A. The filtration system shall be a tertiary cloth media disk filtration by gravity flow. The system shall consist of two filter modules installed in concrete basins to ensure gravity flow compatibility with the existing plant hydraulic profile.

2.2 PERFORMANCE AND CAPACITY REQUIREMENTS

A. Each filter shall meet or exceed the following performance and capacity requirements:

Parameter	Initial	Buildout
Design Flow, mgd	4.0	4.65
Number of Filter Trains, #	2	2
Capacity of each train, mgd (each train to treat 50% of flow for 2+0 system)	2.0	2.33
Maximum Hydraulic Loading Rate, gpm/sq-ft	5.0	5.0
Minimum Disks per Filter Train, each (each train to include space to add disks to achieve buildout capacity)	4	5
Influent Water Quality to the Filters		

Maximum Total Suspended Solids, TSS mg/L	20	
Maximum Chlorine, mg/L	1.5	
Minimum Temperature, degrees C	10	
Filter Effluent Requirements		
Effluent Turbidity, NTU	Max Instantaneous – 5 NTU Max Daily Arithmetic Mean – 2 NTU	Max Instantaneous – 5 NTU Max Daily Arithmetic Mean – 2 NTU
Maximum TSS, mg/l	5	5

2.3 DESIGN AND CONSTRUCTION

A. System Components. Each manufacturer shall provide the components to their standard system in order to meet the performance and capacity requirements discussed herein.
   1. Filter Tank: Each tank assembly shall be concrete and designed by others.
   2. Drive Assembly: The drive assembly shall be designed to rotate the backwash assembly and center shaft during the backwash cycle, if required. Each filter shall include an adjustable drive assembly with a gearbox, drive sprocket, drive chain, and a Type 304 stainless steel chain guard. Belt drive systems will not be acceptable. The gearbox shall be parallel in-line helical type, AGMA class 1 drive motor rated for control by suppliers PLC. The drive sprocket shall be nylon. The chain shall be nylon with Type 316 stainless steel pins.
   3. Center Tube Assembly: If applicable, each center tube assembly shall include a Type 304 stainless steel center tube weldment, driven sprocket, wheel assemblies, and frame and cloth assemblies. The cloth media disk filter may also consist of a centrally located rotating shaft with mounted vacuum shoe assemblies. Each center tube assembly shall also include a chlorine-resistant Viton V-Ring effluent port seal, if required. The driven sprocket shall be multi segment made of UHMW polyethylene. Fasteners shall be type 316 stainless steel.
   4. Filter Cloth Assemblies: Each module shall include sufficient cloth disk assemblies per manufacturers standards to handle initial flows with the capability to expand to handle buildout flows. Each cloth disk assembly shall be comprised of a cloth media sock supported by an injection molded polyethylene copolymer frame or Type 304 stainless steel frame. Cloth/frame assemblies shall be constructed such that each segment is easily removable from the center tube without special tools to allow for removal and replacement of the cloth at the point of installation or maintenance. Systems requiring special tools and/or the return of media segments to the factory for replacement shall not be acceptable.
      a. Cloths shall be of woven nylon or polyester fiber pile construction with polyester backing material having a nominal filtration rating of 5-14 microns. Granular media

and screens having structured identical openings will not be allowed. The cloth media shall have an active filter depth of 3- to 5-mm. The cloth depth shall also provide storage of captured solids, reducing backwash volumes while maintaining an operational headloss. Woven mesh or microstrainer type disk with no filtration depth are not acceptable.

b. Each cloth disk assembly shall have a minimum of 54 - 72 square feet of effective submerged filtration area.
c. Effluent filtration area is defined as only the portion of the disk that is submerged during filtration. Any disk area that is not submerged shall not be considered as effective area.
d. During filtration, the filter unit shall operate in a static condition with no moving parts. The filter system shall provide for the collection of filtered solids on the outside of the cloth media surface to allow for the direct contact of cleaning systems. The filter flow path shall be from the outside of the disk to the inside. Systems with flow paths from the inside to the outside of the disk collecting filtered solids on the interior surfaces of the disk are not acceptable.

5. Effluent Trough: If applicable to the FSS standard, disks may be attached to the effluent trough independently to allow for disk isolation. Disks that are attached to the effluent trough independently shall incorporate a permanently mounted valve for complete isolation and shutoff while the disk is removed from the operating filter. The disk filter design shall sample filtrate from each disk independently or from a common effluent trough, as required.
6. Anchor Bolts: Anchor bolts shall be Type 316 stainless steel. Anchor bolts to be provided by the FSS but installed by the CONTRACTOR.

B. Backwash/Sludge Discharge Assembly: The backwash function shall incorporate a pump that draws filter effluent through the cloth, thereby removing accumulated solids from the cloth surface. Designs that utilize high pressure spray as the sole means of solids removal are not acceptable. The backwash disk filter system shall be suitable for filtering domestic wastewater after conventional treatment. Each filter shall be designed to operate on a continuous basis at peak flow rate and shall be designed to operate while receiving varying flow rates. Backwash can service individual disks or an entire filter system, as required.
1. Each backwash/sludge discharge assembly shall include an external piping assembly, backwash system assembly, and at least one backwash pump. The external piping assembly shall include both automated and manual backwash valves as required for automated operation. Automated backwash valves shall be operated and controlled by the PLC. The backwash assembly shall include molded polyethylene or Type 304 stainless steel backwash shoe supports with end springs if applicable, UHMW backwash shoes, Type 304 stainless steel or wire-reinforced flexible hose, Type 304 or 316 stainless steel backwash manifold with stainless steel hose clamps, and a PVC sludge collection manifold as required. The backwash shoe shall have minimal contact with the cloth media across the entire suction zone in order to reduce wear and solids impingement on the cloth media.
2. Ball valve manufacturers shall be the following or equal:
   a. DeZURIK
   b. GA Industries
   c. Neles-Jamesbury, Inc.
   d. NIBCO, Inc.
   e. Henry Pratt Company

f. Conbraco Industries, Inc. (Apollo)
g. ITT Engineered Valves
h. Watts Regulator
i. Worcester Controls
j. Ta Chen International (TCI), Inc.

3. Gate valve manufacturers shall be the following or equal:
   a. Clow Valve Co.
   b. Kennedy Valve
   c. M & H Valve Company
   d. Milwaukee Valve Company, Inc.
   e. DeZURIK
   f. Fabri-Valves
   g. Mueller Company
   h. NIBCO, Inc.
4. Butterfly valve manufacturers shall be the following or equal:
   a. Bray Series 31 Electric Actuated Lug-Style Butterfly Valves for automatic valves
   b. Bray Series 31 Lug-Style for manual valves
5. The backwash pumps shall be manufacturer's standard and controlled by the supplier's control panel.
6. Filtering shall not be interrupted during normal backwashing and sludge discharge.
7. Each filter shall include backwash control valves and sludge valves as required for automated operation. If applicable, valves shall be 2-inch, 3-piece, grooved or flanged end, 351 CF8M stainless steel body, Type 316 stainless steel ball and stem, full port, installed with cast iron Victaulic couplings and open/close service electric actuator. Valve actuator shall include a compartment heater and thermostat with limit switch feedback to the microprocessor in both the open and closed positions.

C. Swivel Joints
1. If applicable, swivel joints shall be designed to allow rotation of the backwash assembly and center shaft during the backwash cycle.
2. Construction of the swivel joints shall be 304 stainless steel with a permanently lubricated bearing designed for submerged service. Stainless steel shafts shall be precision ground with the machined bearing to insure a precise tolerance.

D. Level Transmitter: A submersible pressure transducer shall be supplied for each filter basin. The pressure transducer shall have stainless steel wetted parts and provide a 4-20 mA signal. Units shall monitor the water level in the filter basin. Pressure transducer shall be provided with a mounting bracket and Type 316 stainless steel anchors. Electrical connection shall be 2-wire, loop powered through a shielded integral cable. The CONTRACTOR shall provide junction box, bellows mounting and interconnecting wiring. Transducers shall be the following or equal:
1. KPSI Model 710 series
2. Endress + Hauser FMX 21 series
3. Rosemount model 3051

E. High Level Switch: A high level mechanical float switch shall be provided to indicate level in the filter modules. Mercury switches are not acceptable. The switch shall be the following or equal:
1. MAGNETROL T20-4 or T21-4
2. Madison M5600

F. Control System: Each disk filter shall have its own control system and shall be supplied by the FSS. The automatic and manual controls for operation of the filter system shall be furnished fully assembled, wired, and pre-programmed in a stainless steel NEMA 4X rated control enclosure. The control system, including equipment, enclosures, and display screens shall be suitably designed for indoor installation in the ambient environment. Controls shall be provided to control and monitor equipment as indicated. The control panel shall be suitable for connection to a single 480 volt, 3 phase, 60 Hz power supply, and shall be equipped with a main circuit breaker disconnect switch, full voltage non-reversing NEMA-rated motor starters, control power transformer, power supplies, and other controls required for a complete and operating system. The control panel shall be equipped with transient voltage surge protection, voltage imbalance protection, motor overload protection, and phase loss protection.

G. Programmable Logic Controller: Automatic operation of the filter shall be controlled through a programmable logic controller (PLC) mounted inside each filter local control panel. The control panel shall be equipped with a PLC suitable for control and protection of the filter systems. PLC shall be an Allen-Bradley 1769 Compactlogix PLC with I/O modules as required by the application. The filter system shall provide hardware I/O points to wire into the plant PLC system to allow for the following data and alarms to be taken directly from the filter controller and imported to the plant PLC and SCADA networks.
   1. Status signals
      a. Filter on-line status.
      b. Filter in backwash status.
   2. Alarm signals
      a. Filter high level alarm.
      b. Filter drive failure alarm.
      c. Backwash pump failure alarm.
   3. The CONTRACTOR shall require the filter manufacturer to coordinate its WORK so that the filter controls are fully integrated with the plant PLC and SCADA system.

H. Operator Interface Terminal: The control system shall be equipped with an operator interface that provides control display screens for the operator to monitor and control filter status, setpoint, and alarm information.
   1. The interface shall allow the operator to adjust the following operating parameters:
      a. Time of day, date, year
      b. Backwash interval
      c. Backwash duration
      d. Sludge waste interval
      e. Sludge waste duration
      f. Number of backwashes between sludge wasting
   2. The interface shall provide information to assist the operator in assessing the status of the filter system. The interface screen shall display, at minimum, the following parameters:
      a. Time of day, date, year
      b. Water level in the filter
      c. Time since last backwash
      d. Time since last sludge withdrawal
      e. Elapsed time on the drive motor
      f. Elapsed time on the backwash pump
      g. Total backwash time

h. Total sludge withdrawal time

3. The interface shall display the alarm history. The alarm history shall include the time and date of the most recent 25 alarms along with the description each alarm. The interface shall also display current alarms, including the date, time, and a description of each alarm. As a diagnostic aid to the operator, the interface shall display the time between backwashes for the most recent 40 backwashes.

I. Filter Supports, Walkways, Handrails and Stairs: Shall be designed and provided by others.

J. The filter supplier shall provide appropriate supports to support backwash piping and utility water piping.

K. Fiberglass Removable Cover: Not required, filters to be located in a covered building designed and provided by others

L. Spare Parts: The CONTRACTOR shall provide spare parts suitably packaged and labeled. As a minimum, the spare parts shall include:

1 spare cloth per complete disk or wedges of a cloth for a complete disk per train	Filter cloths
1	Filter media support frame
1	Viton V-ring effluent port \ centertube seal
1	Actuated valve of each size if applicable

2.4 FILTER MANUFACTURERS

A. Aqua-Aerobic Systems, Inc.

B. Five Star Filtration, LLC.

C. Nexom.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Installation shall be per the manufacturer's printed recommendations and as indicated. Installation shall be under the supervision of a qualified manufacturer representative.

3.2 START-UP SUPERVISION AND INSTRUCTION

A. The equipment manufacturer shall furnish the services of a factory trained representative for a minimum of 3 trips and six 8-hour Days at the Site to inspect the installation, supervise the

initial operation of the equipment, instruct the plant operating personnel in proper operation and maintenance, and provide process assistance during performance testing.

B. The Technical Manual shall be furnished at least 60 Days prior to startup.

3.3 FIELD TESTING

A. Testing: In conjunction with the requirements of Section 01 91 14 – Equipment Testing and Startup, a Performance Test shall be performed once the filters are installed. The CONTRACTOR shall send a 5-gallon filter influent sample to the filter manufacturer a minimum of 2 weeks prior to onsite sampling. This sample will provide the manufacturer a representative sample to perform a laboratory filterability test. Testing shall be conducted by the CONTRACTOR through a testing laboratory approved by the ENGINEER prior to testing. The ENGINEER shall be notified at least 3 Days before the start of any test.
   1. Hydraulic Loading Test
      a. In separate tests, each filter module shall be loaded continuously at the peak flow rate of 2.0 mgd for a continuous 4-hour period. The effluent turbidity shall not exceed an average of 2 NTU over the testing period. If the filter does not meet this performance requirement, the filter shall be inspected, tuned, and retested. The Performance Testing below shall not commence until the requirements of this test have been satisfied by each of the filter modules.
      b. Effluent water quality shall be monitored and reported by a continuous online turbidimeter that draws a sample from the filter effluent chamber. The turbidimeter shall be calibrated immediately before the start of the test.

   2. Performance Test
      a. Influent water quality: The performance test shall be conducted on each filter module using plant secondary effluent after the plant processes have stabilized and the plant is operating normally. Test duration for each module shall be 8 continuous hours at a flow rate of 1.0 to 2.0 mgd with at least 2 continuous hours at 2.0 mgd. The average filter influent TSS concentration will not exceed 20 mg/l during the test period. Composite one liter TSS samples will be taken every hour. A TSS analysis for each sample shall be performed by a certified lab.
      b. Effluent water quality: Effluent water quality will be monitored and reported by a continuous online turbidimeter that draws a sample from the Reuse Pump Station Wet Well. The turbidimeter shall be calibrated immediately before the start of the test.

   3. Performance test outcome: The performance test will result in one of 3 outcomes, pass, fail, or process upset. These are described below as well as follow-up procedures for each outcome.
      a. Pass: The pass outcome demonstrates that the filters met the required turbidity requirements during the performance test period with no filter equipment failure during the test. The follow-up for this outcome is to draft the Performance Test Report defined below.
      b. Fail: If the filter was unable to meet the effluent requirements with all influent water quality requirements satisfied, the CONTRACTOR may conduct a maximum of 2 additional performance tests. If the filters fail either of those tests, they will be considered defective WORK.

c. Process Upset: If there is a process upset that compromises the influent water quality and interrupts the performance test, the upset shall be noted and documented in the Performance Test Report. The tests shall be repeated after process stability is reestablished.

4. Performance test report: A performance test report shall be drafted to describe the results of each performance test conducted. The report shall include the following:
   a. Title Page
   b. Table of Contents
   c. Executive Summary: This section shall contain a brief introduction describing the purpose of the test. The summary shall also include the flow rate and resulting hydraulic loading rate, average influent TSS concentration (mg/l), average effluent turbidity values (NTU), volume of the waste washwater as percent of influent flow as well as total number of waste washwater cycles. A graph shall show both influent TSS (mg/l) and effluent turbidity versus time. A general statement comparing the overall performance of the filters to the requirements shall also be included.
   d. Hydraulic Loading Rate: The flow rate (mgd) and hydraulic loading rate (gpm/ft^2) shall be discussed in this section. Average turbidity results shall be presented. Flow data will be included in the Appendix. The results of the hydraulic loading test shall be presented and discussed.
   e. TSS data: This section shall display the influent TSS values (mg/l) graphically over the test period. The lab reports shall be included in an Appendix. A brief narrative about the data shall also be part of this section.
   f. Turbidity data: This section shall present graphically the continuous turbidity measurements (influent and effluent) over the performance test time period. A graph shall also be included showing both influent TSS (mg/l) and effluent turbidity versus time. The reported effluent turbidity will be measured by the turbidimeter located at the Reuse Pump Station Wet Well. A brief narrative about the turbidity data shall be given in this section as well. The rate of chemical addition shall be included in the report.
   g. Waste washwater: The volume of waste washwater as percent of influent flow shall be presented in this section. The number of waste washwater cycles and a brief narrative describing the overall effectiveness of the cycle shall also be given in this section.
   h. Overall performance: This section shall describe the reason for any performance test restarts resulting from either test fail outcomes or process upsets. The section will also provide a general summary of the overall performance of the filters and any problems that were encountered during the testing.
   i. Appendix: The Appendix shall contain continuous influent flow data and graph, as well as the certified lab data and reports and any other important information pertaining to the performance test not already included in the report.

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SECTION 46 61 25
CLOTH MEDIA FILTERS - APPENDIX

A.1 Utah Type I Requirements

State of Utah water quality requirements for use of treated effluent within secondary irrigation systems (Type I Reuse) governed by Utah Administrative Code R317-3. Requirements are summarized in Table ES-2 from the Preliminary Engineering Report (PER).

Table ES-2
Utah Type I Requirements

Parameter	Notes	Unit	Type I	Notes
BOD	Monthly arithmetic. mean; 24 hr composite; n=6	mg/L	10	1
Turbidity	Daily arithmetic mean	NTU	2	2
	Maximum instantaneous	NTU	5	2
E-Coli	Weekly median	#/100 mL	ND	2
	Maximum daily grab	#/100 mL	9	
Residual Chlorine	Continuously measured	mg/L	1	3
pH	Daily grab samples or continuous monitoring	SU	6 to 9	

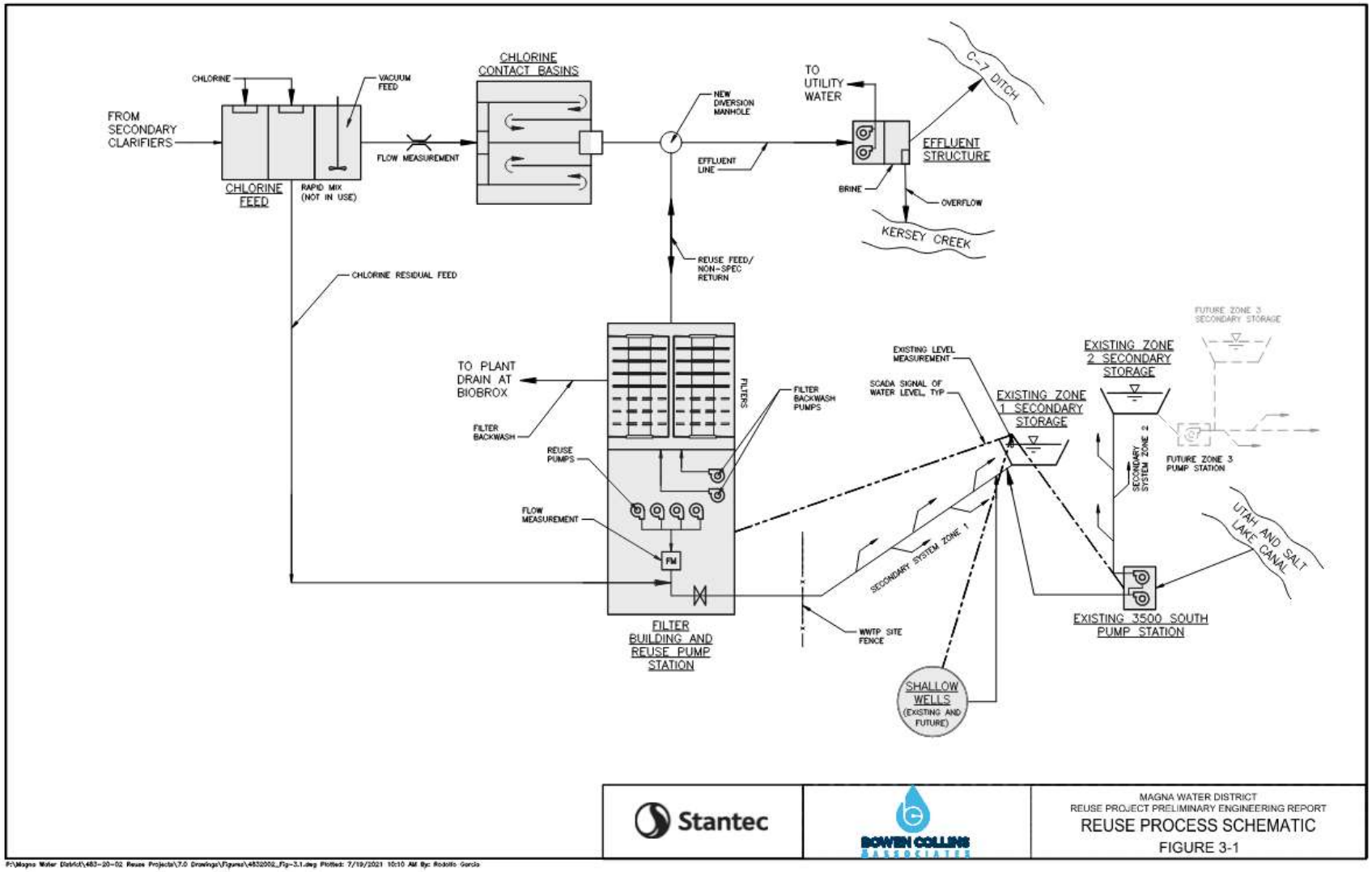
1. Monthly Reports provide daily grab samples. Revisit sampling methodology and frequency for reuse design basis.
2. Data not available. Revisit sampling methodology and frequency for reuse design basis, as needed.
3. Data continuously below requirement; this will be addressed under Task 3 for potential disinfection improvements and operational practices.

A.2 2019-2020 Effluent Water Quality, Before and After Brine Diversion

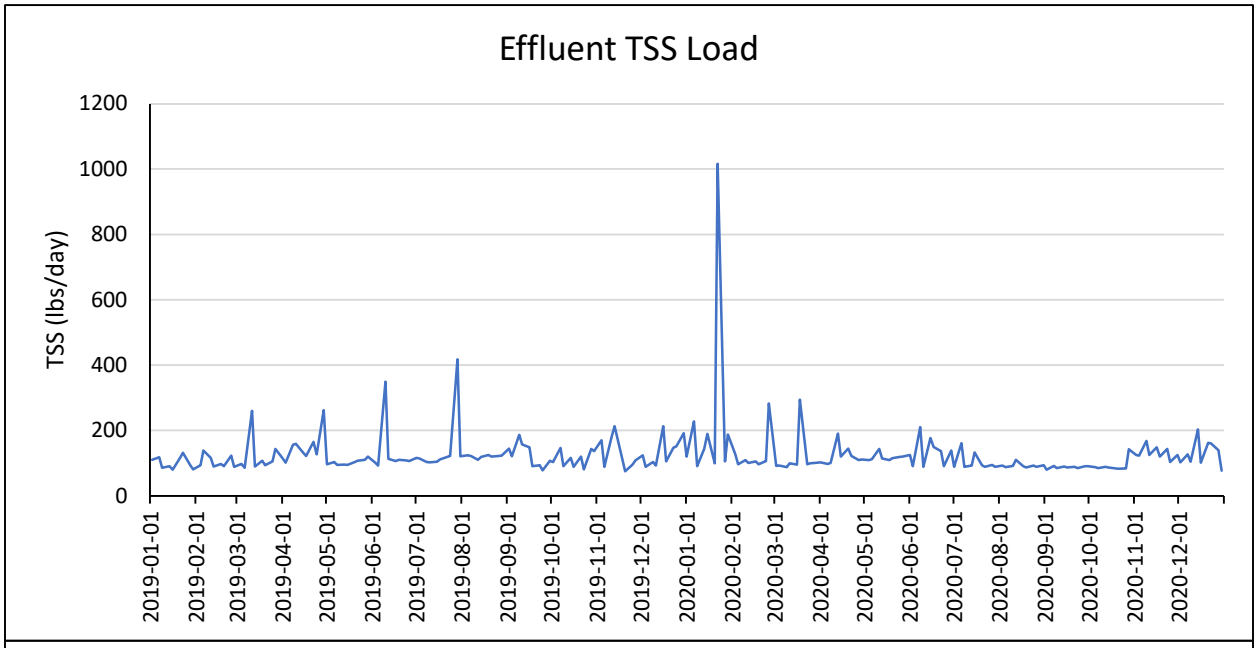
Table 2-5
2019-2020 Effluent Water Quality, Before and After Brine Diversion

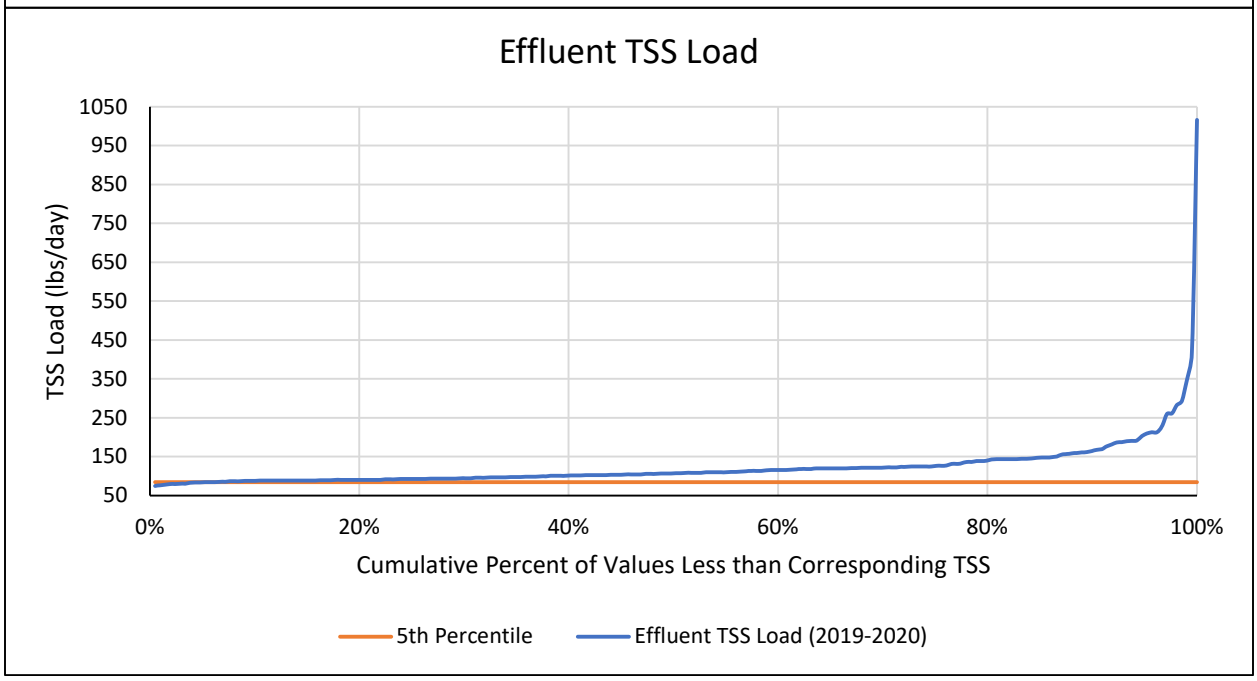
Timeframe		1 January 2019 - 31 December 2020				3 June 2020* - 31 December 2020				Comparison		
Parameter	Unit	Minimum	Average	Maximum	No. Samples	Minimum	Average	Maximum	No. Samples	Minimum	Average	Maximum
Average Day Effluent Flow	MGD	1.5	2.9	4.1	731	2.3	2.6	3.1	212	-0.8	0.3	1.0
Adjusted Effluent Flow	MGD	1.1	2.6	3.6	731	2.3	2.6	3.1	212	-1.2	-0.1	0.5
pH	SU	7.0	7.6	8.3	731	7.0	7.4	8.3	212	0.0	0.1	0.0
BOD	mg/L	5.0	6.5	20.0	209	5.0	6.4	16.0	61	0.0	0.1	4.0
TSS	mg/L	4.0	5.2	44.0	209	4.0	5.1	10.0	61	0.0	0.1	34.0
Turbidity	NTU	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Phosphorus (as P)	mg/L	1.5	2.0	2.8	24	1.5	1.9	2.3	6	0.0	0.1	0.5
Ortho Phosphate (as P)	mg/L	1.0	1.7	2.5	24	1.0	1.5	1.9	6	0.0	0.3	0.6
E-Coli	#/100 mL	1	9	165	208	1	5	32	60	0	4	133
TDS	md/L	1,020	1,353	1,630	9	1,020	1,115	1,290	4	0.0	238	340
Chlorine Residual	mg/L	0.4	0.7	0.8	731	0.4	0.6	0.8	212	0.0	0.1	0.0

A.3 Proposed Magna WRF Reuse Process Schematics

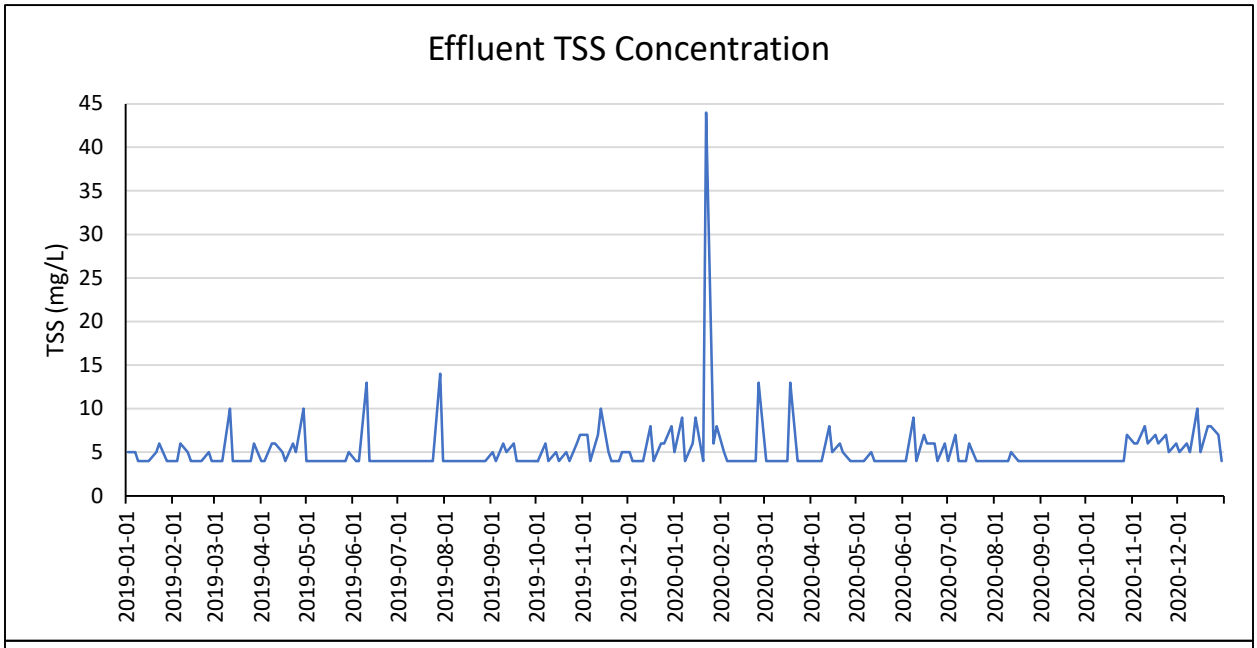


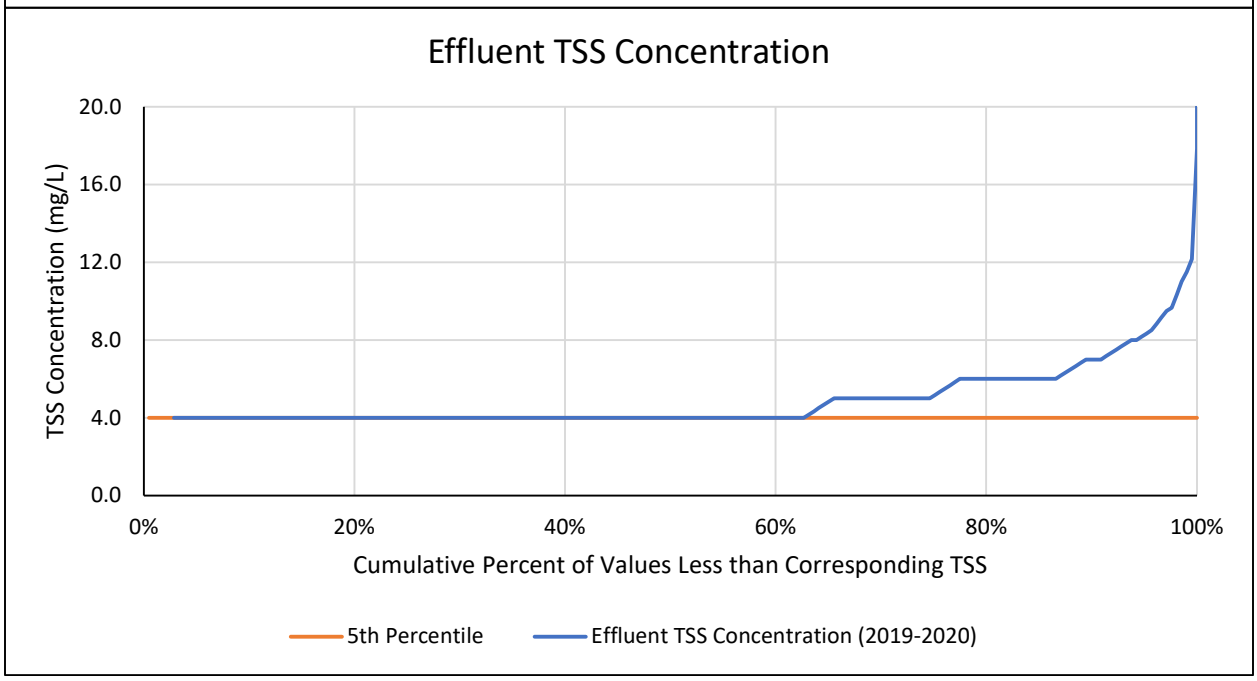
A.4 Historical Effluent TSS from Magna WRF





A.5 Historical Effluent TSS Concentration from Magna WRF





A.6 Recently Collected Turbidity Data 2022

Date	Time	Turbidity (NTU)
8-Dec-22	7AM	1.5
	12PM	2.8
	4PM	2.1
15-Dec-22	7AM	2.8
	12PM	2.9
	4PM	3.2
22-Dec-22	7AM	2.4
	12PM	3.2
	4PM	2.7
29-Dec-22	7AM	2.5
	12PM	2.1
	4PM	2.3
6-Jan-22	7AM	3.07
	12PM	3.96
	4PM	2.35
19-Jan-22	7AM	1.57
	12PM	1.76
	4PM	1.57
27-Jan-22	7AM	1.4
	12PM	-
	4PM	-
Minimum Turbidity		1.4
Average Turbidity		2.43
Maximum Turbidity		3.96
Median Turbidity		2.4

19-Jan-22	
Time	**Turbidity**
8:00 AM	1.57
9:00 AM	2.15
10:00 AM	2.31
11:00 AM	2.48
12:00 PM	1.76
1:00 PM	1.98
2:00 PM	1.3
3:00 PM	1.57
Minimum Turbidity	**1.3**
Average Turbidity	**1.89**
Maximum Turbidity	**2.48**
Median Turbidity	**1.87**

A.7 TSS EFFLUENT WATER QUALITY DATA 2019 – 2020

1 January 2019 - 31 December 2020							
Parameter	EFFLUENT						
	Average Day Effluent Flow	Adjusted Effluent Flow	pH	BOD	TSS	BOD	TSS
	MGD	MGD		mg/L	mg/L	lbs/day	lbs/day
Minimum	1.491	1.140	7.0	5.0	4.0	93	75
Average	2.887	**2.553**	7.6	6.5	5.2	159	125
Maximum	4.102	3.608	8.3	20.0	44	598	1016
Median	2.812	2.566	7.6	5.0	4.0	133	108
Mode	2.667	2.692	7.6	5.0	4.0	116	89
92nd Percentile	3.501	2.818	7.8	10.0	8.0	258	184
95th Percentile	3.587	2.876	7.8	12.2	9.0	300	207
# Sample Points	731	731	731	209	209	209	209

3 June 2020* - 31 December 2020							
Parameter	EFFLUENT						
	Average Day Effluent Flow	Adjusted Effluent Flow	pH	BOD	TSS	BOD	TSS
	MGD	MGD		mg/L	mg/L	lbs/day	lbs/day
Minimum	2.294	2.294	7.0	5.0	4.0	100	77
Average	2.621	**2.621**	7.4	6.4	5.1	141	111
Maximum	3.137	3.137	8.3	16.0	10.0	404	210
Median	2.634	2.634	7.4	6.0	4.0	117	93
Mode	2.692	2.692	7.2	5.0	4.0	111	89
92nd Percentile	2.810	2.810	7.8	10.0	7.2	216	161
95th Percentile	2.839	2.839	7.9	11.0	8.0	273	168
# Sample Points	212	212	212	61	61	61	61

*Based on average effluent flow data, the brine flows were removed from the plant flows starting on 3 June, 2020

#N/A for mode means that every value is unique

A.8 E-Coli Readings 2020 Magna WRF

E-Coli Readings 2020 MW WWTP												
Sample #	January	February	March	April	May	June	July	August	September	October	November	December
1	50	1	5	1	5	1	9	12	9	1	7	3
2	48	2	21	38	7	1	3	7	1	4	9	6
3	22	2	1	4	11	10	6	2	3	2	6	3
4	165	10	19	1	3	1	24	1	1	3	5	1
5	4	27	6	12	48	18	5	1	1	2	9	19
6	1	25	11	19	19	12	18	1	1	4	4	4
7	1	3	3	12	10	9	10	1	1	3	2	1
8	83	7	3	29	5	11	1	3	5	2	2	1
9	49	1	13	19	6	1	6	9	5	2	8	4
10	93	6	10	2	7	5	15	1	2	2	5	2
11	2	26	8	15	33	15	11	1	1	3	6	11
12	42	5	3	20	7	10	5	2	2	2	2	1
13	71	3	11	10	6	3	10	5	3	2	6	3
14	22	15	5	17	20	12	8	1	1	2	4	6
15	46	9	8	13	13	7	9	3	2	2	5	4
7 Day Average	93	26	13	20	33	15	15	9	5	3	8	11
30 Day Average	46	9	8	13	13	7	9	3	2	2	5	4

A.9 E-Coli Readings 2021 Magna WRF

E-Coli Readings 2021 MW WWTP												
Sample #	January	February	March	April	May	June	July	August	September	October	November	December
1	1	3	38	1	2	2	5	14	3	1	2	
2	1	4	83	1	3	8	15	1	1	1	1	
3	1	1	1	1	9	12	11	5	1	16	1	
4	1	1	1	1	15	18	16	6	4	5	1	
5	1	3	22	3	1	18	3	5	1	15	2	
6	2	32	3	5	4	6	1	3	9	22	1	
7	2	32	10	1	1	8	3	2	1	5	1	
8	1	25	7	7	4	15	1	15	1	27	1	
9	1	3	60	1	2	5	10	7	2	1	2	
10	1	1	1	1	12	15	13	6	3	11	1	
11	1	17	2	4	2	12	2	4	5	19	2	
12	1	28	8	4	2	11	2	9	1	16	1	
13	1	2	30	1	7	10	11	7	3	6	2	
14	1	22	5	4	2	11	2	7	3	18	2	
15	1	12	17	2	4	10	6	7	3	12	2	
7 Day Average	1	28	60	4	12	15	13	9	5	19	2	
30 Day Average	1	12	17	2	4	10	6	7	3	12	2	